



EPA FACILITIES MANUAL, VOLUME 1

ARCHITECTURE, ENGINEERING, AND PLANNING GUIDELINES

FEBRUARY 1998

The EPA Facilities Manual

The *EPA Facilities Manual* is comprised of four distinct, yet complementary resources for planning and managing Environmental Protection Agency (EPA) facilities. These four volumes are meant to be used simultaneously to determine design intent, requirements, and the ongoing evaluation of all EPA facilities. The use of one volume without reference to the other three would result in an incomplete understanding of the requirements for EPA facilities.

- Volume 1: The *Architecture, Engineering, and Planning Guidelines* (referred to as the *AE&P Guidelines*) provides guidance for facilities management, engineering, planning, and architecture professionals in the design and construction of new EPA facilities and the evaluation of existing facilities.
- Volume 2: *Space Guidelines, Volume I* contains information on space planning, space estimation, environment, materials, furniture, process, and maintenance. EPA's Office of Administration and Resources Management developed this document to help EPA facilities managers, space managers, and line personnel plan and use their space.
- Volume 3: *Space Guidelines, Volume II* is a technical handbook describing EPA's mission and providing space standards, information on technical considerations and materials safety, and other related documents. It is also intended for use by EPA facilities managers, space managers, and line personnel.
- Volume 4: The *Facility Safety, Health, and Environmental Management Manual* (referred to as the *Safety Manual*) outlines safety, health, and environmental management considerations for owned or leased EPA facilities. The Manual's goal is to maintain a safe and healthful workplace that protects against injury, illness, and loss of life.

Architecture, Engineering, and Planning Guidelines

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APPENDICES

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INDEX

Introduction

PURPOSE

The *Architecture, Engineering, and Planning Guidelines* (hereafter referred to as either the *AE&P Guidelines* or this Manual) is a compilation of generic information that shall be used in conjunction with the *Facility Safety, Health, and Environmental Management Manual* (the *Safety Manual*) as the basis for the Program of Requirements (POR) and Solicitation for Offers (SFO) for new construction (including additions and alterations) of Environmental Protection Agency (EPA) laboratory facilities projects and for the evaluation of existing facilities. This Manual is not a Program of Requirements or a Solicitation for Offers but is a set of standards and guidelines to be used for a number of purposes. It shall be used alongside codes and regulations to develop construction documentation for EPA facilities. This Manual is restrictive only in that it is a set of guidelines and minimum standards. It is intended to be used throughout the design process, with the concurrence of EPA, to develop and establish solutions that meet the requirements established herein in the form of construction documents for public bidding and the award of construction contracts.

Citations of standards, codes, or references within this Manual should be assumed to refer to the most current edition. Years and publication dates specifically stated in the Manual reflect the version in use when the Manual was originally written and published. When using this Manual, the user should verify that the documents referenced are the most current and have not been superseded.

The primary purpose of this Manual is to establish a consistent, Agencywide level of quality and excellence in the planning, design, and construction of all EPA facilities projects. The Manual provides basic standards and guidelines for design and construction. It is not intended to deter use of more stringent or greater performance criteria for design. Project-specific design and construction requirements that are not in conflict with the requirements of this document should be met in developing the final program. The generic information and requirements described herein must be verified and further defined and refined. They are used in specific design cases.

ORGANIZATION OF THE MANUAL

This document is generally organized according to the *Masterformat*, published by the Construction Specifications Institute (CSI). The 16-section format, outlined below, should be familiar to many in the fields of architecture, planning, engineering, and construction. When used throughout this Manual, the term “new construction” shall be understood to include additions and alterations to existing buildings.

SECTION 1: GENERAL PLANNING AND DESIGN DATA

This section provides information on EPA’s planning goals, which may relate to any specific project. The various project-specific EPA offices and their organizations are defined, and the planning objectives and criteria are documented. The requirements that may apply to a specific project are compiled, and the project-specific requirements documented, in an overview and summary fashion. General facility requirements will be unique to each project. This section outlines the categories that should be addressed.

The section mixes project-specific information with guidelines that may be used for all projects. It provides an overview of new construction and describes the major elements of, and information for, any project for which predesign and conceptual design can be performed. Section 1 sets the tone for any specific project design and its development. The general information in Section 1 shall be carefully modified to be made project specific. Section 1 also contains an outline for lease administration and offer requirements, which shall also be made project specific.

- SECTION 2: SITE WORK**
Section 2 provides site and civil requirements for EPA facilities. In addition to technical requirements relating to site work, this section contains design criteria and landscape requirements.
- SECTION 3: CONCRETE**
Section 3 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 4: MASONRY**
Section 4 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 5: METALS**
Section 5 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 6: WOOD AND PLASTICS**
Section 6 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 7: THERMAL AND MOISTURE REQUIREMENTS**
Section 7 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 8: DOORS AND WINDOWS**
Section 8 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 9: FINISHES**
Section 9 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 10: SPECIALTIES**
Section 10 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 11: EQUIPMENT**
Section 11 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 12: FURNISHINGS**
No information specific to furnishings is included in this manual. Information on Green specifications can be obtained from the Architecture, Engineering and Real Estate Branch (AEREB) and the Green Buildings Council.
- SECTION 13: SPECIAL CONSTRUCTION**
Section 13 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.
- SECTION 14: CONVEYING SYSTEMS**
Section 14 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.

Introduction

SECTION 15: MECHANICAL REQUIREMENTS

Section 15 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.

SECTION 16: ELECTRICAL REQUIREMENTS

Section 16 contains standards and guidelines that apply to all new construction and alterations, along with some project-specific information.

APPENDICES Several appendices are included with this document. They contain certain necessary project-specific and generic information, descriptions, procedures, and data that are required for the project but are too lengthy and detailed to be included in the main document. Included in these appendices are guideplates of room data and floor plans for specific room types. These guideplates illustrate minimum dimensions, handicapped access, equipment, furnishing layouts, and specific room requirements for finishes; heating, ventilation, and air-conditioning (HVAC); electrical power; plumbing; and communications.

INDEX The Index provides an alphabetical listing of topics contained in this Manual referenced to paragraph numbers.

USE OF THIS MANUAL

This Manual does not relieve the architects, engineers, and consultants of any of their responsibilities as design professionals. It is intended only to clarify and supplement existing codes and requirements to facilitate the design process for the design professional and the offeror. The architect, engineers, and consultants who will be involved in the design of an EPA-occupied laboratory, office, or storage facility shall be licensed professionals in their fields of expertise and shall be experienced in the design of such facilities. They will be required to ensure that all portions of the project comply with all established applicable codes, regulations, and practices for laboratory facilities, as well as with this Manual.

This document establishes basic design parameters. It is a set of standards and guidelines that must be used in programming and designing a laboratory.

FORMATTING AND PARAGRAPH NUMBERING

The paragraphs in each section of this Manual are considered to be subsections and are identified by a hierarchical numbering system. When a paragraph is not numbered, it should be considered part of the preceding subsection. When subsections from this Manual are used in the project-specific manual, the subsections shall have the same numbers that they have in this Manual. Because the subsections of the project-specific manual are not renumbered, the project-specific manual can be directly compared and referenced to subsections in this generic Manual. When subsections from this Manual are not used, those numbers are omitted from the project-specific manual. As an alternative, the project-specific manual may contain all subsection numbers from this Manual, with the notation “this subsection not used” inserted after those numbers not included in the project-specific manual.

END OF INTRODUCTION

Section 1 - General Planning and Design Data

1.1 General Scope of Project

1.1.1 PURPOSE

A description and purpose of any proposed new facility shall be provided. The following questions are among the items to be addressed when a new facility is under consideration:

- Does the new facility construction replace an old facility or a number of facilities?
- Does the new facility construction represent expansion of an existing facility or the addition of new square footage without moving the current operation?
- Does the new facility construction represent consolidation?
- Has a specific site been established?
- Are there special studies that must be performed early in the project development, such as analysis of whether a group must consolidate or whether more or less space is required?
- Is the proposed project required for the upgrade and/or improvement of the efficiency of existing operations?

1.1.2 PLANNING STUDIES, EVALUATIONS, AND REPORTS

A list of all planning documents, studies, evaluations, and reports shall be provided, along with an executive summary of their conclusions and results.

1.2 Background Information

1.2.1 EXISTING FACILITY DESCRIPTION

A brief overview and description of all existing facilities, and of the campus if the facilities are so composed, shall be provided. The use of photographs is encouraged.

1.2.2 FACILITY AND CAMPUS COMPONENTS

A more descriptive short subsection on each component of the facility or campus shall be provided.

1.2.3 FUNCTIONAL ORGANIZATION

A brief introductory description of the organization of the various branches and laboratories in the project and how they interrelate, and a more detailed description of each branch and laboratory, shall be provided.

1.3 Planning Requirements

1.3.1 PLANNING GOALS

A brief description of the goals of the Environmental Protection Agency (EPA) and of the subgoals required to reach each goal shall be provided for any given project. The goals and subgoals should state which current conditions are good or correct and must be maintained and which current conditions are not good or not correct and must be resolved or improved. Each subgoal should state any new condition that must be met. Examples are as follows:

- Increase interaction and communication among offices and laboratories, among all laboratories, and/or among all offices, as necessary.
- Improve circulation for safety and to minimize travel distances and time.
- Consolidate laboratories if such consolidation is necessary and feasible.
- Anticipate expansion.
- Zone and separate according to function.
- Share resources.
- Design laboratories according to a modular design plan.
- Design the typical laboratory module for flexibility.
- Increase efficiency of laboratory module.
- Increase flexibility and adaptability.
- Decrease maintenance costs.
- Enhance image.
- Enhance quality of life.
- Increase personnel safety.
- Define spaces or functions that must be adjacent to one another.

1.3.2 PLANNING OBJECTIVES

Each of the goals listed under Planning Goals shall be defined, and the specific subgoal shall be stated. Each requirement shall also be noted and described.

1.3.3 PLANNING CRITERIA

Planning criteria must be established and agreed upon in order to establish the net design area for the project (net design area is defined in subsection 1.5.3). There are likely to be several categories of space, such as office spaces, laboratory spaces, specialized spaces, and storage spaces. An additional category, exterior areas, contains space not directly included within the facility and not included in net design area.

1.3.3.1 GROSS AND NET AREA

Gross area represents all net area plus all additional space required to provide a complete and functioning facility (e.g., egress and other required corridors, stairs, restrooms, mechanical and electrical rooms, interior and exterior walls, building structure, shafts and similar nonoccupied or nonoccupiable spaces, and construction). Net area is the gross area less circulation and utility spaces, as defined by the General Services Administration (GSA). The net area divided by the gross area yields the percentage design efficiency of the facility. Definitions of net usable and gross usable area (which are distinct from net and gross design areas) can be obtained from the EPA project officer.

1.3.3.2 INCLUSION OF EXTERIOR AREA

Exterior area is space that is not included within the facility buildings but that must be on the facility site. This space may be open air and unprotected, such as storage areas for vehicles; semienclosed (for instance, under a shed roof or in a fenced enclosure), such as fuel storage areas; or totally enclosed, such as a remote power plant for support services.

1.3.3.3 OFFICE SPACE

Planning criteria must be established for general office and interior support spaces. Criteria may be established by using the GSA formula, which sets primary square footage for office space for clerical, administrative, paraprofessional, professional, managerial, and executive personnel at 125 net square feet per person plus an additional 22 percent, or 27½ net square feet per person, for support areas. Support areas do not include storage or specialized spaces. Thus, with this method, 152½ net square feet are allocated per individual. EPA must agree upon the method to be used to establish square footage. The above (GSA) method of determining general office and interior support space shall be followed unless specific and demonstrated functional requirements would justify doing otherwise.

1.3.3.4 LABORATORY-RELATED OFFICE SPACE

Laboratory personnel who must also evaluate and interpret data and prepare written reports and manuscripts must have some office space outside of the laboratories where they work. The size of these offices should be computed as indicated in subsection 1.3.3.3. The same standards utilized for the regular office spaces are applicable to these office spaces, with the added provision that the laboratory-related office space should be located as close as possible to the laboratory space to which it relates. Laboratory-related office space shall not be included within the physical laboratory room.

1.3.3.5 LABORATORY SPACE

Planning criteria must be established for modular laboratory space. Square footage may be set at 308 net design square feet per module. On the basis of EPA functions and tasks, a module size of 11 feet by no less than 26 feet and no more than 33 feet has been established as the standard that must be followed in all laboratories except those where functions and tasks would justify using a different standard.

1.3.3.6 SPECIALIZED SPACE

Specialized spaces include special laboratories that do not fit a set module and require square footages significantly greater than those needed for standard laboratories. Such spaces include pilot plant operations and animal care facilities. These spaces may or may not need to be located with other modular laboratory space or office space.

1.3.3.7 STORAGE SPACE

Storage spaces, as herein classified, represent large open storage areas that are required to support specialty or specific functions; these include, in addition to standard storage space, storage space that is part of laboratory or office space. This storage space may have to be adjacent to or near a laboratory or remote from the new facility.

1.3.3.8 DAY-CARE FACILITIES

Day-care centers must comply with National Fire Protection Association (NFPA) 101, Life Safety Code, as well as with EPA's guidelines, GSA's *Child Care Center Design Guide* (PBS-PQ140), and the licensing requirements of the local jurisdiction. Refer to the *Safety Manual* for minimum requirements.

1.4 Scope of Requirements

1.4.1 GENERAL

A brief overview of the scope of the specific project requirements shall be provided.

1.4.2 CODES

A brief statement about applicable local codes that must be followed shall be provided here, with a reference to Appendix A, Codes, Regulatory Requirements, Reference Standards, Trade Organizations, and Guides. This reference shall include a statement noting that not all potentially applicable codes, requirements, references, organizations, and guides may be listed. Include the occupancy classification of the facility and reference to compliance with applicable codes. A code review document shall be produced that documents the research performed to comply with all applicable codes. This document shall be updated, at a minimum, at the end of each phase of the project.

1.4.3 FACILITY ORGANIZATION

Program function statements shall be provided for each of the offices, branches, and laboratories involved in the project and for their interrelationships.

1.4.4 SUMMARY OF REQUIREMENTS

A general description of the required total net area of the new facility shall be provided, excluding all exterior areas. A general description of the net exterior area shall be provided.

1.4.4.1 FACILITY SUMMARY

A general listing of net assignable space shall be provided in net area for each of the following types of space:

- Office space
- Modular laboratory space
- Specialized space
- Storage space
- Exterior areas
 - Vehicle holding
 - Fuel storage
 - Hazardous material/waste storage.

1.4.4.2 NET AREA SUMMARY

A sample summary chart of total net area is provided in Table 1.4.4.2, Net Area Summary.

1.4.4.3 PERSONNEL SUMMARY

A sample summary chart of personnel, by organization and group, is provided in Table 1.4.4.3, Personnel Summary.

Section 1 - General Planning and Design Data

Table 1.4.4.2 Net Area Summary		(Example for Illustration and Format Only)				
		Net Area (square feet)				
EPA Building		Office	Lab	Special	Storage	Total
ORD		127,900	137,597	99,535	15,470	380,722
	HERL	41,283	73,350	38,733	2,890	158,256
	OD	1,375	0	1,320	600	3,295
	NTD	6,937	11,110	1,210	220	19,477
	GTD	10,138	16,720	1,870	0	28,728
	RSD	6,000	1,100	30,583	1,410	39,093
	DTD	6,650	15,180	1,440	0	23,270
	ETD	10,183	31,240	2,310	660	44,393
	AREAL	54,325	42,120	22,305	9,080	128,050
	OD	4,950	0	990	5,200	11,140
	ACMD	14,375	9,680	3,190	440	27,685
	MRDD	10,500	12,100	8,985	220	31,805
	HEFRD	9,625	6,920	4,840	3,200	24,585
	QATSD	7,500	9,020	3,860	0	20,380
	EERD	7,375	4,400	440	240	12,455
	AEERL	20,670	16,590	33,482	1,100	71,842
	OD	3,035	0	6,402	0	9,437
	GECD	8,170	3,520	3,840	0	15,530
	PCD	9,465	13,070	23,240	1,100	46,875
	ECAO	9,372	0	1,400	1,600	12,372
	OSORD	2,250	3,537	3,615	800	10,202
OAR		55,030	4,620	9,385	3,680	72,715
	OAQPS	55,030	4,620	9,385	3,680	72,715
	OD	2,935	0	2,455	0	5,390
	ESD	20,900	0	1,680	400	22,980
	AQMD	19,195	0	3,650	640	23,485
	TSD	12,000	4,620	1,600	2,640	20,860
OARM		71,125	0	100,415	10,023	181,563
	OARM	71,125	0	100,415	10,023	181,563
	OD	2,250	0	600	150	3,000
	CMD	7,000	0	1,920	738	9,658
	HRMD	3,500	0	1,920	300	5,720
	NCPD	11,250	0	2,525	300	14,075
	FMSD-O	6,250	0	11,505	3,385	21,140
	FMSD-C	6,250	0	23,980	0	23,980
	NDPD	40,875	0	57,965	5,150	103,990
Total		254,055	142,217	209,335	29,173	635,000

The above acronyms are sample organizational codes. Each major organization must be subdivided into its component groups.

Table 1.4.4.3 Personnel Summary (Example for Illustration and Format Only)

EPA Building		Number of Personnel		
		Office*	Technician**	Total
ORD		893	428	1,321
	HERL	254	295	549
	OD	11	0	11
	NTD	42	46	88
	GTD	55	89	144
	RSD	48	35	83
	DTD	40	45	85
	ETD	58	80	138
	AREAL	417	60	477
	OD	22	60	82
	ACMD	115	0	115
	MRDD	84	0	84
	HEFRD	77	0	77
	QATSD	60	0	60
	EERD	59	0	59
	AEERL	142	73	215
	OD	23	4	27
	GECD	58	23	81
	PCD	61	46	107
	ECAO	62	0	62
	OSORD	18	0	18
OAR		418	0	418
	OAQPS	418	0	418
	OD	19	0	19
	ESD	160	0	160
	AQMD	143	0	143
	TSD	96	0	96
OARM		567	108	675
	OARM	567	108	675
	OD	18	0	18
	CMD	56	0	56
	HRMD	28	0	28
	NCPD	90	0	90
	FMSD-O	50	0	50
	FMSD-C	0	0	0
	NDPD	325	108	433
Total		1,878	536	2,414

* Office personnel working in laboratories are shown only as office occupants.

**The term "technician" refers to laboratory personnel who do not have office space outside of the laboratory area.
This is done so that the total personnel count reflects an accurate head count of people.

The above acronyms are sample organizational codes. Each major organization must be subdivided into its component groups.

1.5 Facility Design and Layout

1.5.1 OVERVIEW

In general, the information contained in this document must apply to existing buildings as well as to any possible new construction. EPA can only present the generic space requirements, identify the types of spaces anticipated for the various functions of the facility, identify general technical requirements, and give general guidance for actual layout. This subsection contains design requirements that shall be used as guides and references. In addition, model room data sheets are included in Appendix C with examples that provide general, and some specific, program requirements. Specific program criteria and space identification and sizes shall be developed during the programming phase of the specific project. The purpose of the programming phase is to determine the quantitative and qualitative requirements of the specific program and to relate these requirements to the available budget. Specific project criteria and requirements must be verified with EPA. The design professional must work in close coordination with EPA to produce the final building layout in accordance with this document and the guidance gained through consultation with EPA. Appropriate local, state, and federal regulatory agencies shall also be consulted.

1.5.2 SITE DEVELOPMENT

Design and layout requirements relating to the facility site and exterior environment are discussed in Section 2, Site Work, of this Manual.

1.5.3 PROGRAMMED SPACE FOR DESIGN AND LAYOUT

The final accepted program shall establish the definite net design area requirements for the facility and shall establish gross and net area requirements for the exterior areas of the project. Exterior areas are areas that are not contained within the building envelope of the main facility but must be on-site. An understanding of the design efficiency of the facility and all exterior areas provides the foundation for the layout of all on-site requirements. EPA may require additional space in remote facilities; however, these facilities are not a part of the program established by this document.

1.5.3.1 EFFICIENCY

Net design area for the project is established by the planning goals and objectives and the planning criteria defined in subsection 1.3. The planning goals and objectives, along with the established typical generic or specific laboratory requirements, as defined in the room data sheets included in Appendix C, produce a design efficiency for research facilities of this type (ratio of net to gross area). Generally, the design efficiency ratio ranges from approximately 50 percent to 65 percent, with an average efficiency of approximately 58 percent.

1.5.3.2 EXPANSION

Providing for future expansion is an integral part of the requirements for any new EPA project. The design professional shall review and/or confirm with EPA all anticipated expansion needs and shall recommend methods of accommodating expansion to meet these anticipated needs, as well as addressing future expansion beyond the anticipated needs. The design professional shall be responsible for recommending the direction(s) of expansion, after consultation with EPA. All expansion shall be accommodated in a logical manner, both programmatically and by construction sequencing. For new construction, EPA expects provision for a 25 percent expansion.

- Corridor layout and circulation patterns shall enhance flexibility and aid in future expansion. Open plans, which allow greater flexibility in expansion and general facility changes, are encouraged where feasible, practical, and permitted by EPA.
- Floor plans that encircle a department with permanent corridors, stairs, mechanical and electrical rooms, or other fixed building elements that are difficult to relocate should be avoided.

- Column-free functional areas should be maximized, and use of transfer beams should be minimized.
- Anticipated expansion must be reviewed by representatives of all disciplines on the project.
- Expansion space shall be designed for each type of space used in the facility and for parking facilities.
- Electrical, mechanical, plumbing, and other support systems should be designed and sized to permit modification and expansion with the least cost and least disruption to overall operations.
 - Utilities and support services, such as heating, ventilation, and air-conditioning (HVAC); plumbing; and electrical systems, shall allow expansion or contraction in the services provided. The location of utilities and support services and the size of lines, method of connection, and valving shall be such as to minimize interruption of service, maximize the systems' accessibility to the space they service, and allow access to each module of the system for service and repair without disrupting services in other modules.
- Design drawings that show existing building and site conditions along with proposed building and site designs are required to show both proposed building and expansion areas. All drawings shall be at the same scale. Enlarged studies of selected areas may be included. However, EPA desires a complete overview massing of the entire site for each proposed design, with expansion and flexibility clearly defined.

1.5.4 PLANNING OF EXTERIOR AREAS AND FACILITIES

The types of spaces included as exterior areas are listed in subsection 1.3.3.2. Information for specific facility design and layout is provided in subsection 1.5, Facility Design and Layout, and subsection 2.4, Site Development. Exterior areas may include the following areas and facilities:

1.5.4.1 OUTSIDE SERVICE AREAS

Outside service areas comprise:

- Meters
- Vaults
- Transformers
- Dumpsters
- Compactor units
- Emergency generators
- Oxygen tank/manifold
- Pressure reducers
- Valves
- Pump hoses
- Loading docks.

1.5.4.2 ANCILLARY FACILITIES

Ancillary facilities are appurtenant facilities that are required by the building program and must be located immediately outside of a laboratory or specialty space or in close proximity to that space.

1.5.5 ARCHITECTURAL REQUIREMENTS

The architectural design of all EPA facilities must meet the requirements set forth in the following subsections. Goals and guidelines to be considered in the architectural design process are also presented.

Section 1 - General Planning and Design Data

1.5.5.1 GENERAL

The architecture of any proposed EPA facility shall be functional and flexible—capable of keeping pace with the changes that are continually occurring in EPA programs. Facility components shall be organized in a functional and aesthetic manner, according to a modular design concept that addresses the needs of all users of the facility. The facility should blend in with its natural and man-made environment. The design should provide for reduced energy consumption as called for in these design guidelines.

1.5.5.1.1 LIGHTING

Use of natural light should be maximized where possible. Proposed nonlaboratory work areas that are above grade and contiguous with an outside wall shall have windows. Goals set forth in EPA's Green Lights Program shall be followed throughout the facility.

1.5.5.1.1.1 LABORATORY LIGHTING

Lighting considerations for laboratory space include adequate task lighting; use of natural lighting, where feasible; and reduced energy consumption.

- Laboratories require a high quality of lighting for close investigative work in order to eliminate eye strain and fatigue. Task lighting must be bright, uniform, and glare free. Lighting fixtures must be so positioned as to provide shadow-free illumination of the laboratory work area.
- The introduction of natural light into the laboratory provides operators with an opportunity for visual relief from the pressures and stress of the work environment. This issue presents design challenges in large, multistoried facilities and has significant impact on planning and functional zoning concepts. Whenever possible, and unless achievement of this end is in direct conflict with functional requirements, laboratories shall be located in a way that maximizes natural daylight. Windows in laboratory spaces shall be fixed-panel, nonoperable windows. Laboratories utilizing photographic and optical diagnostic techniques shall have blackout capability.

1.5.5.1.2 QUALITY-OF-LIFE STANDARDS, LABORATORIES

This subsection establishes quality-of-life standards for laboratory spaces in the facility. Comfortable work environments stimulate productivity, enhance recruitment, and help EPA retain top scientific investigators.

1.5.5.1.3 FLEXIBILITY AND ADAPTABILITY

The building itself and all of its systems—architectural, mechanical, and electrical—shall be as flexible and adaptable as possible because functions and related laboratory operations often change. The proposed building(s) and systems shall allow for future space adjustments with minimal disruption to ongoing activities.

1.5.5.1.4 MODULAR DESIGN

Modular design is the concept upon which flexible laboratory facilities are based. In this design, the laboratory module represents the fundamental planning and organizing element. The discipline of repetitiveness and regularity of size, shape, and arrangement of space provides the ability to convert and renovate space quickly on the basis of each investigator's unique set of laboratory design requirements and demands.

1.5.5.1.4.1 PLANNING MODULE

The laboratory planning module establishes a dimensional discipline for dividing space and a method of calculating laboratory systems requirements and distribution concepts. The intent is to determine common denominators for space and systems that will accommodate a variety of functions and uses. As changes are required, the modular planning approach allows the expansion,

subdivision, or reconfiguration of rooms without disturbing adjacent spaces or altering or forcing shutdown of, central building utility systems.

- A modular design is required. The planning module size represents the size thought to be most responsive to user requirements. The design professional shall, therefore, study the requirements, evaluate the equipment and instrumentation needed for each laboratory, and either use the planning module size or propose other module sizes that architecturally and operationally will provide the required features.
- The structural system shall allow for future changes in various mechanical and utility services. Floor-loading capability shall be uniform throughout the building to permit space usage conversions.
- Laboratory systems capacity must be determined on the basis of a common per-module denominator that anticipates future needs. In this determination, each module represents a unit of capacity for the building system (e.g., gallons of water, watts of power, cubic feet per minute [cfm] of supply and exhaust air). This generic method of calculating systems distribution ensures adequate building utility systems capacity and prevents costly shutdown and reconstruction of primary building systems components.
- Modular laboratory design shall integrate primary building systems (HVAC, piping, electrical power, and communications) into a distribution loop with modulated, consistent, recurring points of distribution relative to each planning module. These points of distribution give each module access to all laboratory systems; any additional services required in the future can easily be extended from the main distribution loop to the point of use. Each module shall have a readily accessible disconnect from each building system.
- Building systems must be readily accessible for maintenance and servicing. Components that require routine servicing should be located in corridor ceiling spaces or other spaces outside the laboratory perimeter. Servicing building systems components inside the laboratories is disruptive and difficult because of the amount of scientific equipment that must be protected. Whenever systems components are placed above ceilings, a lay-in type ceiling should be used, or access panels installed, to facilitate access for servicing and maintenance.

1.5.5.1.4.2

SIZE OF LABORATORY MODULE

The size of a laboratory module shall be as follows:

- The width of the laboratory module shall always be at least 11 feet, from the centerline of the walls framing the laboratory module.
- The depth of a laboratory module should not be less than 26 feet or more than 33 feet. Within these limits, size shall be determined on the basis of the task requirements and shall be consistent throughout a given block of laboratory rooms within a laboratory building.

1.5.5.1.4.3

EXPANSION

Recognizing the probability of future expansion, a plan should be established that zones the facility horizontally and/or vertically and accommodates future growth in a logical manner. This plan must establish a framework for central building systems, which framework can easily be extended or added to depending on the amount of growth.

1.5.5.2 ENTRANCE REQUIREMENTS

All entrances to the facility must be clearly defined. There shall be only one main entrance, although access to this main entrance may be from a variety of directions. The following are general design requirements for the main entrance:

- Means of egress shall comply with all applicable codes, with particular attention to the fire safety requirements in NFPA 101 and Chapter 4, paragraph 4, of the *Safety Manual*.
- The main entrance shall be consistent with the design of the facility. The design of the space(s) and the material selection shall express EPA's and the facility's position in the world environmental community. Materials shall be high quality and durable.
- All entry spaces should be open, airy, and inviting to the entrant.
- The main entrance must be easily recognizable and allow easy transition to other facility areas by first-time users of the facility.
- The building subdivisions and the arrangement of exits, corridors, vestibules, lobbies, and rooms should allow fast and orderly exit in case of emergency and provide appropriate security for personnel, property, and experiments. The facility and interior modules shall have controllable access, which should ensure a safe and secure working environment.
- A security control station shall be at the main entrance, and security personnel shall have good visual control over the building's main entrance and lobby space, as well as monitor control over all other exits and entrances.
 - Often a full-time security station is not economically justified by the amount of staff and visitor traffic through the main entrance of the facility. The receptionist may need to fulfill the security role.
- Administrative areas shall be near security control stations.
- The receptionist shall support the security control staff, and the reception and security control areas shall be at the same location within the entrance/lobby area.
- The lobby shall be sized and designed to accommodate the special concerns of tours while maintaining discrete security and function.

1.5.5.3 AMENITIES

A workplace that encourages communication, interaction, and collaboration among its users enhances worker productivity and increases employee retention. Staff interaction, especially in laboratory facilities, must be promoted by the design solution. Functional organization and relationships that promote such interaction must be utilized. Strategic location of common support areas (i.e., conference rooms, restrooms, coffee and vending areas, clerical support services, and supplies) and carefully considered circulation patterns shall be incorporated to foster meaningful interaction. It is also important to provide a place to safely consume food and drink outside of the laboratory. Building amenities must be dedicated, neutral spaces that are protected from encroachment and future conversion.

1.5.5.4 HANDICAPPED ACCESS

The design and layout of an EPA facility must ensure that the facility is accessible to the physically challenged, in accordance with the Uniform Federal Accessibility Standards (UFAS) (1988) adopted by the GSA in 41 CFR Parts 101-19.6, the Americans with Disabilities Act (ADA), and all other applicable federal, state, and local laws and standards for buildings and facilities required to be accessible to and

usable by physically challenged people (barrier-free design). Where different laws and standards are in conflict, the most stringent code shall apply. If there is difficulty in determining which code is most stringent, the Government reserves the right to make the final decision on the interpretation of all codes.

1.5.5.4.1 GENERAL ACCESSIBILITY

General access to the facility and any portion thereof shall be based on common sense design and shall comply with all applicable standards, guidelines, and codes, including ADA and GSA 41 CFR Parts 101-19.6. EPA recognizes that the facility will not be designed only for physically challenged individuals. All applicable requirements shall be clearly understood, and the final design shall not only meet these requirements but shall apply their essence in a commonsense manner throughout the facility. At a minimum, the design shall meet and exceed all applicable standards, guidelines, and codes. Other aspects of general access are as follows:

- Avoid crossing pedestrian and vehicular circulation paths.
- Provide adequate circulation space at points of traffic congestion and provide architectural features that emphasize overall circulation patterns and major entrances.
- Avoid confusing corridor systems and extensions of through corridors from department to department.
- Avoid horseshoe-shaped major corridor systems that require excessive walking distances.
- Avoid dead-end departmental corridors.
- Minimize single-loaded corridors.
- Eliminate major corridors through elevator lobbies or through other areas that tend to concentrate circulation patterns.
- Locate vertical transportation so that it is visible from major entrances.

1.5.5.4.2 LABORATORY ACCESSIBILITY

Accommodating the handicapped in a laboratory demands a design that is flexible, adaptable, and common sense. The environment must function properly within handicapped regulatory requirements of the law and must offer safety for the users. Casework in all laboratories shall be capable of being modified to meet accessibility requirements at minimum cost. Some general criteria for handicapped accommodation in laboratories are as follows:

- The handicapped-accessible workstation shall provide a work surface that is 30 inches above the floor, with all wheelchair clearances below. Adjustable work surfaces that provide a range of height adjustments shall be considered for all such workstations.
- Utilities, equipment, and equipment controls for laboratory furniture should be within easy reach of persons who are physically handicapped and have limited mobility. Controls shall have single-action levers or blade handles for easy operation.
- Aisle widths and clearances shall be adequate for maneuvering of wheelchair-bound individuals. Aisle widths of 60 inches are required.
- Handicapped-accessible workstations shall be located as close to laboratory exits and safety showers as possible.

1.5.5.5 EXTERIOR BUILDING MATERIALS

In selecting building materials, careful consideration shall be given to all technical criteria.

1.5.5.5.1 EXTERIOR ELEMENTS

Mechanical, electrical, transportation, and equipment elements that are to be located on the exterior of the facility shall be integrated elements of the design. These elements include air intake and exhaust vents, exterior lights, utility connections, plumbing vents, fuel tank vents, liquid oxygen tanks, transformers, trash compactors, containers, loading docks, condensers, cooling towers, and mechanical equipment.

Mechanical equipment should not be located on roofs, due to vibration concerns, unless it is totally impractical to do otherwise. If mechanical or other equipment is located on the roof, particular attention must be paid to the vibration and to isolating such vibration inside the building. The equipment must also be aesthetically screened. Screening shall be designed to aesthetically hide the equipment and to prevent the entrance of rain into the fresh-air intakes of the facility and to prevent entrainment of laboratory exhaust air into the fresh-air intakes of the facility and adjacent facilities.

1.5.5.5.2 DESIGN CHARACTERISTICS

The design characteristics of wall schemes shall be evaluated in terms of aesthetics, function, and cost effectiveness with respect to the following:

- Moisture transport.
- Thermal performance.
- Aesthetic appropriateness.
- Historic considerations (if applicable and appropriate).
- Durability (life cycle maintenance costs).
- Exterior wall termination at the roof or top of parapet walls (including penthouse).
- Construction and control joint locations, considering impact on construction sequence and building movement due to expansion and contraction.
- Corner conditions, especially material relationships at the intersection of vertical planes and the continuity of wall supports and flashings.
- Load transfer of the wall to the structure, including consideration of structural frame exposure and lateral wall supports.
- Weathertight design, including sealant profiles, material adjacencies, and flashing configuration.
- Window placement relative to the wall, secondary connection requirements, material adjacencies, window washing, glass type and thickness, and life safety hardware.

Refer to Section 7, Thermal and Moisture Requirements, of this Manual for additional information on exterior building requirements in relation to thermal and moisture protection.

1.5.5.6 PARTITIONS

Standardization of interior partitions is desirable. Partitions within the administrative area should be easily removable. Sound isolation and laboratory partitions between modules shall be designed to be removable in order to accommodate future reconfiguration of spaces.

1.5.5.6.1 SUBDIVIDING PARTITIONS

Office subdividing partitions shall comply with the applicable local building code requirements. These partitions must be provided at a ratio of 1 linear foot per 10 square feet of space. Partitioning over interior office doors is included in the measurement. Partitions must extend from the finished floor to the finished ceiling and have a flame spread rating of 25 or less, a smoke development rating of 450 or less (American Society for Testing and Materials [ASTM] E-84 Test), and a minimum sound transmission loss (STL) rating of 40.

1.5.5.6.2 PERMANENT PARTITIONS

Permanent partitions must be provided, as necessary, to surround stairs, corridors, elevator shafts, toilets, janitor closets, meeting and conference rooms, and mechanical rooms. They shall have a flame spread rating of 25 or less and a smoke development rating of 450 or less (ASTM E-84 Test). Stairs, elevators, and other floor openings shall be enclosed by partition(s) and have the fire resistance required by applicable codes. These partitions shall extend from the floor to the underside of the structure above, shall effectively isolate sound and vibration, and shall meet all fire separation requirements.

1.5.6 SPACE IDENTIFICATION

Specific information will be provided for each project.

1.5.7 SPECIFIC ROOM REQUIREMENTS

This subsection describes information and design requirements for specific rooms and areas.

1.5.7.1 ROOM DATA SHEETS

A typical room data sheet, which can be used for various anticipated functions, is contained in Appendix C, along with examples of how to use room data sheets. These room data sheets must indicate specific room or laboratory requirements and identify appropriate installed equipment. Location of fume hoods within laboratory spaces shall conform with the specifications of Appendix C, as applicable. The design professional will be responsible for the final design for these areas, after consultation with representative facility users and approval by EPA.

1.5.7.2 STANDARDS AND SYMBOLS

In addition to specific requirements, standard requirements for each area and room must be identified in the various sections of the guidelines. An annotated example of a listing and definitions of standard requirements, symbols, and abbreviations (where used) shall be presented in this subsection of the project-specific manual.

1.5.7.3 SPECIAL EQUIPMENT

The list of movable equipment and furnishings required on the room data sheets is meant to provide assistance in determining the anticipated demand loads for electrical, HVAC, plumbing, specialty gas, and other piped services connections. All special equipment will be furnished by EPA unless otherwise identified during the program verification and design phase of the specific project. The exceptions are major fixed pieces of equipment requiring hard-connected electrical and piped utility services and HVAC (e.g., fume hoods, environmental rooms, glassware washers). Each room and area housing special equipment must have the utilities, electrical power, and HVAC capability necessary to ensure the equipment's proper and efficient operation.

1.5.8 GUIDE FOR ARCHITECTURAL LAYOUT

The concept for architectural layout should be to group all administrative functions and all technical functions into separate organizational blocks of space while keeping them sufficiently close together to facilitate and encourage employee interaction. The guiding principle in developing this basic concept shall be the separation of the facility into three definable zones: administrative with support, laboratory, and building support. This division will allow not only the most flexibility for facility design, but also the most cost-effective construction. In reference to the interior space of a building or facility, the following definitions apply:

- Rooms and spaces refer to individual divisions of space, each one usually defined or enclosed by partitions or walls.
- Blocks are groups or series of rooms or spaces, usually having similar orientation and adjacencies.
- Zones are composed of two or more blocks of spaces, often providing the same or similar functionality.

1.5.8.1 ADJACENCIES

The building design concept shall establish the appropriate horizontal and vertical alignments of the facility to facilitate required programmatic relationships. Floor plate areas shall be optimized to accommodate the required occupancies and to allow for future expansion or alterations.

1.5.8.1.1 LABORATORY ZONE

This zone shall include all laboratories and laboratory support blocks within an individual branch or section. Laboratory-related office blocks shall be located in close proximity to related laboratories and laboratory support blocks. These offices shall be across from related laboratory space or in “clusters” along a laboratory related corridor. The laboratory block(s) shall utilize a modular laboratory planning concept to maximize flexibility and adaptability of research space. Window exposure for both offices and laboratories should be maximized.

1.5.8.1.2 ADMINISTRATIVE-WITH-SUPPORT ZONE

The administrative-with-support zone should be physically separated from the laboratory zone in the same building. Building links between the administrative-with-support zone and the laboratory zone shall house pleasant and comfortable interaction spaces, such as a lounge. Administrative-with-support spaces shall include, but shall not be limited to, break areas, restrooms, copier areas, mailrooms, and conference areas.

1.5.8.1.3 BUILDING SUPPORT ZONE

The building support zone should be located adjacent to the laboratory zone to facilitate the movement of equipment and material to and from the laboratories. Its location shall be determined in accordance with the site master plan and should optimize service vehicle circulation. The building support zone design shall house a receiving dock, facility physical plant, mechanical equipment, and central storage. An isolated hazardous materials/waste storage facility (HMSF) shall be located near this zone to facilitate transportation and handling of explosive/flammable materials, toxic chemicals, and biohazardous waste before disposal at an off-site location by a licensed contractor.

1.5.8.2 BUFFER ZONES

The buffer zone between the EPA facility and other existing or potential sites for building(s) shall be no less than 100 feet. The HMSF shall be at least 50 feet away from any building or potential sites for building(s). Both the main facility and the HMSF shall be located at least 50 feet away from the property line. Existing highways and streets can be part of the 100-foot buffer zone. Paved parking area(s) for vehicles can be considered as part of the building buffer zone.

1.5.8.3 TECHNICAL SPACE

Research support personnel (i.e., technicians, postdoctoral employees, laboratory assistants) should be provided with work space outside of the laboratory room in order to minimize long-term exposure to laboratory chemicals and the hazards presented by their use. Technician space, such as shared offices, alcoves, and cubicles, does not have to be directly outside of the laboratory as long as it can be placed reasonably close to the laboratory. Some desktop work space should also be provided in the laboratory for laboratory-related reporting and documentation that should not be done at the laboratory bench. These workstations, where provided, must be so located as to minimize exposure to noxious, or otherwise hazardous, conditions. The supply air and exhaust distribution system within the laboratory must be carefully coordinated with the designed work space to provide one or more “clean air” zones. In some instances, a physical separation, or barrier, may be required between the work space and the laboratory bench.

1.5.8.4 LABORATORY SUPPORT BLOCK

The laboratory support block is defined as the space that houses common, or shared, activities or equipment, such as analytical instrumentation, specialized equipment, environmental rooms, and glassware preparation areas, that indirectly support laboratory activities. These spaces can be interspersed between laboratories, supporting a specific activity, or can be grouped together adjacent to a block of laboratories. Particular attention shall be paid to functional relationships among laboratory support spaces and laboratories, with an emphasis on the efficiency of the travel path of personnel, tasks, and material within a particular zone and between zones.

1.5.9 ENVIRONMENTAL DESIGN REQUIREMENTS

The facility shall be designed to conserve energy, to avoid the use of construction materials insensitive to the environment, to efficiently utilize water, to promote effective recycling, to be free of radon, to have excellent indoor air quality, and to avoid the use of ozone-depleting chemicals.

1.5.9.1 GENERAL

The architectural and engineering design of the facility shall use proven methods, strategies, and technologies exhibiting respect for, and protection of, the environment. These methods, strategies, and technologies include the selection of site, materials, and construction systems that prevent infiltration of radon; to the extent possible, the use of recycled construction materials and construction materials produced with minimal expenditure of energy; and use of insulation, fire protection, and refrigeration systems that avoid use of chlorofluorocarbons (CFCs) and other ozone-depleting chemicals. The facility shall also be designed to promote the use of natural light and to afford optimum use of energy-efficient lighting systems (e.g., ballasts, task lighting). The facility shall be designed to meet the requirements of the EPA Internal Pollution Prevention Program. All EPA buildings should be designed to meet ecological design criteria, which include maximum use of natural light, Green Lighting, light fixtures operated by sensors, recycled material, and other devices that save energy without jeopardizing safety. This section of the project-specific manual should state that the facility design must meet the requirements of the following Executive Orders and Memorandum: Executive Order 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements; Executive Order 12873, Federal Acquisition, Recycling and Waste Prevention; Executive Order 12902, Energy Efficiency and Water Conservation at Federal Facilities; Executive Order 12843, Procurement Requirements and Policies for the Federal Agencies for Ozone-Depleting Substances; Executive Order 12845, Requiring Agencies to Purchase Energy Efficient Computer Equipment; the presidential memorandum on environmentally beneficial landscaping; or any subsequent or superseding Executive Order relating to the protection of the environment.

1.5.9.2 ENERGY-CONSCIOUS DESIGN

Fundamental design decisions related to energy conservation shall be made during the planning stages. The new design shall utilize passive design techniques to minimize heating and cooling loads. These techniques include:

- Siting of facilities in relation to sun path, wind, and vegetation.
- Efficient design of building form and envelope in response to climate.
- Reducing cooling load through use of daylighting.
 - The use of natural but controlled daylighting shall be maximized to the extent that it does not conflict with other EPA energy conservation objectives. EPA values natural light and considers it part of a good working environment. The building organization and design concept shall consider bringing natural light into personnel spaces.
 - Size, number, and location of windows shall be determined on the basis of need for natural light and ventilation and of other energy considerations. All windows in heated or air-conditioned spaces shall be double-glazed, insulated windows. Low E glass should be used for all exterior windows. Laboratory windows shall be fixed-pane, nonoperative windows. In an air-conditioned building where office windows are operative, these windows must have a removable operating handle.
- Reducing solar heat gains through proper design of solar-shading devices combined with proper selection and location of building materials. Laboratory windows in particular are sensitive to solar gain and should be shaded on the exterior from direct rays with efficient devices.
- HVAC systems designed for an integrated, energy-conserving facility.

In addition, the new facility shall meet energy efficiency standards set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE 90-1, 1989) for new buildings. The building design, and all construction features (materials and methods of installation, including mechanical and electrical systems) shall provide concepts that will reflect reduced energy consumption.

1.5.9.3 CONSTRUCTION MATERIALS

EPA wishes to take a very active role in the selection of the materials used in the project and during the construction process. In this regard, the design professional, in close coordination with EPA, shall carefully examine the environmental sensitivity of materials and products specified for construction and build-out for the new facility. EPA will encourage minimal use of products that are insensitive to the environment during and after manufacture.

1.5.9.3.1 MATERIALS TO BE AVOIDED AND/OR NOT USED

These materials are as follows:

- Insulation containing CFCs and other refrigerants harmful to the environment.
- Products that off-gas chemical pollutants and whose presence is hazardous (e.g., formaldehyde-treated materials, especially materials containing urea-formaldehyde). (See also EPA/400/1-91/033, *Building Air Quality: A Guide for Building Owners and Facility Managers*, December 1991.)
- Products that are not biodegradable when repaired or removed.

- Products that contain asbestos.
- Lead-containing plumbing, lead-based solder, lead-soldered tanks and valves. These should not be used for potable drinking water supplies. Drinking water plumbing products (faucets, valves, fittings, piping, etc.) shall be prohibited from use in EPA facilities unless they bear the National Sanitation Foundation (NSF) standard 61 certifying mark indicating compliance with USEPA Safety Drinking Water Act.

1.5.9.3.2 MATERIALS TO USE

Materials must meet the following requirements:

- Interior architectural systems must be made of nontoxic materials and components and be free of asbestos, lead-based paints, and toxic fumes. (See the *Safety Manual*.)
- Materials should minimize the depletion of natural resources and should not require a high energy input to produce.
- Sanitation finishes shall be nonpermeable, noncorrosive, easily cleaned, and easily maintained.

1.5.9.3.3 RECYCLED CONSTRUCTION MATERIALS

Under Section 6002 of the Resource Conservation and Recovery Act (RCRA), EPA has set guidelines, which apply to federal, state, and local procuring agencies using appropriated federal funds, for purchasing items composed of the highest practicable percentage of recovered materials. EPA wishes its facility to follow the guidelines, Procurement of Building Insulation Products Containing Recovered Materials, 40 CFR Part 248, February 17, 1989, and Cement and Concrete Containing Fly Ash, 40 CFR Part 249, January 28, 1983, within the constraints of cost and required technical performance.

1.5.9.3.4 BUILDING SHELL MATERIALS

The external treatment and materials utilized shall be of proven long-term durability and require minimum maintenance. The quality of materials shall be consistent with the image and dignity appropriate to a U.S. agency. Material selection should be based on an anticipated 100-year life cycle.

1.5.9.4 RECYCLING

The facility shall be designed to support an aggressive solid waste management plan. The facility design shall properly locate, and provide for, spaces that facilitate the collection, separation, compaction, storage, and shipment of all recyclable materials. General office space, freight elevator area, shipping and storage area, and loading docks shall be designed with this important activity in mind.

1.5.9.5 RADON ABATEMENT

EPA seeks to limit the presence of radon and radon daughters in the new facility. Site geological surveys shall be carefully examined to obtain predictive radon infiltration data from subgrade geological structures. Building materials, such as concrete aggregate and stone, shall be selected from sources with low probabilities of radioactivity. The level of activity in any area of the building shall not exceed 4 picocuries per liter (pCi/L) of air. In areas known to have high radon in structures, buildings shall be designed to include preventive techniques such as caulking of all joints between concrete slab and walls below grade, caulking of all pipe penetrations, and venting of all nonoccupied spaces below grade.

1.5.9.6 ELECTROMAGNETIC FIELDS

EPA seeks to limit the presence of electromagnetic fields (EMFs) in close proximity to people within the new facility. Prudent avoidance is required in the routing of electrical power. EPA recommends that the routing of power throughout the facility be well away from people and offices; for instance, elevator electrical chases and other electrical chases should be located away from offices and on exterior walls.

1.5.9.7 WATER CONSERVATION

EPA requires that the design of new facilities minimize water consumption through the use of water-saving measures. The facility design shall make use of gray-water recycling where feasible, flow-restricting spray nozzles for faucets and showers, and low-flow flushments for fixtures, and shall optimize the sizing of all plumbing systems.

1.5.9.8 OZONE DEPLETION PROTECTION

Any contribution to depletion of the ozone layer of the geosphere by the use of CFCs will be discouraged. EPA requires that selection of materials and processes using CFCs be consistent with the guideline goals related to Protection of Stratosphere Ozone, 40 CFR Part 82, August 1988.

1.5.9.8.1 CHLOROFLUOROCARBONS

Current recommendations, guidelines, and requirements shall be reviewed and addressed.

1.5.9.8.2 REFRIGERANTS

Equipment in an EPA facility may use any significant new alternatives policy (SNAP) approved refrigerant with zero ozone depletion potential for electrically driven screw or centrifugal chiller designs. (See Chapter 7 of the *Safety Manual*.) In addition, a design professional shall specify which portable refrigerant reclamation/recycling unit is used with each refrigeration system, excluding water-cooled centrifugal chillers. Ventilation requirements for the chiller plant(s), new or existing, shall comply with ASHRAE standard 15-1991, Safety Standard for Mechanical Refrigeration.

1.5.9.8.3 HALON

Use of halon for fire protection systems is prohibited. To obtain the most current list of alternatives approved under SNAP, call the Stratospheric Ozone Protection Hotline at 1-800-296-1996 or access the associated Internet site at <http://www.epa.gov/docs/ozone/title6/snap/snap.html>.

1.5.9.8.4 INSULATION

All work shall be done in accordance with EPA's recommended uses of hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) in replacing CFC-based insulation. (See also Chapter 7 of the *Safety Manual*.)

1.5.9.9 INDOOR AIR QUALITY REQUIREMENTS

Refer to Appendix B of this Manual for the indoor air quality requirements.

1.6 Special Room Requirements

1.6.1 RESTROOMS

Each men's and women's restroom that is located in the laboratory area shall have shower stalls and adequate lockers for the laboratory operation and the number of people, men and women, who may be required to use it. All sanitation finishes shall be nonpermeable, noncorrosive, and easily maintainable.

1.6.1.1 FINISHES

All restrooms shall have ceramic tile to a height of 4 feet 6 inches and wall covering of not less than 13 ounces per square yard or equivalent quality, as approved by the contracting officer, on remaining wall areas, unless an alternate finish is approved by the contracting officer.

1.6.2 JANITOR CLOSETS

Janitor closets shall be provided in sufficient numbers to service the various areas of the building(s). Each block shall have at least one janitor closet with mop sink. These rooms shall be equipped with exhaust ventilation and louvered doors.

1.7 Hazardous Waste Handling

1.7.1 GENERAL DESIGN ISSUES

Safe handling and storage of hazardous materials within the laboratory spaces, and in the facility generally, shall be provided. A system for managing hazardous waste materials for the facility must be carefully planned with EPA and the facility users. The plan shall consider receiving, storage, distribution, use, and waste removal for all materials utilized in the laboratory spaces of the facility. To reduce the quantities of hazardous materials stored in the laboratories, the plan must provide for centralized storage areas specifically designed to store and dispense hazardous materials.

1.7.2 RADIOISOTOPES

Requirements for laboratories using radioisotopes vary depending on the quantity and energy level of the isotopes utilized. The design professional shall be responsible for verifying and evaluating with the users of the facility the specific project requirements for the safe storage and handling of radioisotopes. A space shall be provided near the loading dock of the facility where radioisotope waste containers can be marshaled for removal from the facility by a certified radioisotope waste contractor.

1.7.3 CHEMICAL STORAGE AND HANDLING

Ventilated cabinets (vented to the outside, either directly, by manifolding, or by connection to fume hood exhaust stack) must be provided for collection of waste in each laboratory. A central area must be provided for collection and storage of chemical waste for disposal where the chemical waste disposal contractor can collect the waste for removal from the facility. Refer to the following subsection.

1.7.4 HAZARDOUS MATERIALS/WASTE STORAGE FACILITY

The storage of flammable and combustible liquids shall comply with the restrictions set forth in 29 CFR Chapter XVII, paragraph 1910.106(a), (b), (c), (d), (e), and (f). The primary purpose of the HMSF is to house large quantities of hazardous and flammable materials away from the main laboratory facility and other structures. The determination of "large quantities" shall be made in conjunction with the facility used and the Safety, Health and Environmental Management Division (SHEMD). This facility shall be constructed for the highest hazard rating per applicable building code and in accordance with NFPA 30, Flammable and Combustible Liquids Code. The facility shall be located at least 50 feet from the main facility and from the property line and shall contain fully enclosed rooms for the separate storage of drum containers, flammable and combustible liquids, toxic chemicals, and acids. Cylinder gases may be in an open space part of the facility, as long as the space meets all applicable code and safety requirements. If the HMSF is located less than 50 feet from the main facility, then the two must be separated by appropriate fire separation. Whenever possible, and where required by weather conditions, the HMSF shall be connected to the main laboratory by a covered walkway.

1.8 Security

1.8.1 ACCESS AND EGRESS

The building subdivisions and the arrangement of exits, corridors, vestibules, lobbies, and rooms shall allow fast and orderly exit in case of emergency and provide appropriate security for personnel, property, and experiments. The facility, buildings, and interior modules shall have controllable access, which should ensure a reasonably safe and secure working environment.

1.9 Structural Design Requirements

1.9.1 GENERAL

This section applies to the structural elements of buildings and other incidental structures. The structural elements include, but are not limited to, the following:

- All floor, roof, and wall framing members and slabs.
- All piers, walls, columns, footings, piles, and similar elements of the substructure.
- All other substructures and superstructure elements that are proportioned on the basis of stress, strength, and deflection requirements.

1.9.1.1 MATERIAL, FRAMING SYSTEMS, AND DETAILS

Material, framing systems, and details shall be compatible with the following:

- Clear space and span requirements.
- Serviceability requirements.
- Applicable fire protection classification, applicable local building code, and/or NFPA 220, as applicable.
- Security requirements.
- Foundation conditions.
- Future expansion requirements.
- Architectural requirements.
- Climatic conditions.
- Structural design loads for the specific facility and location.

1.9.1.2 CONSTRUCTION MATERIALS AND LABOR

Local availability of construction materials and labor force shall be considered in the selection of the structural system.

1.9.1.3 DESIGN CRITERIA

The structural design drawings shall indicate the design criteria; the structural materials and their strengths, with applicable material standards; the design loads, including loads that can occur during construction; and the allowable foundation loads that were used in the design.

1.9.2 CALCULATIONS

Calculations shall be prepared and presented as stated in the following paragraphs.

1.9.2.1 GENERAL

All design (including calculations) shall be performed and checked by a registered structural engineer. All calculations shall be on 8½-by-11-inch paper. Calculations shall be indexed and every page numbered. Dividers shall be placed between distinct sections. A summary shall be included describing the type of structure and indicating the live load capacity of each floor and roof.

1.9.2.2 MANUALLY PREPARED CALCULATIONS

Manually prepared calculations shall be neat and legible. Each sheet shall indicate the structural consultant's firm name, address, and telephone number. Each sheet shall indicate the designer's name or initials, the checker's name or initials, and the date prepared. Design assumptions regarding live loads, material strengths, conditions of fixity, etc., shall be clearly stated. Calculations shall be sufficiently cross-referenced that a third party can review the calculations without requiring additional information.

1.9.2.3 COMPUTER ANALYSIS AND DESIGN

Computer software used for structural analysis and design shall be from a nationally recognized vendor. Each separate run shall indicate software licensee, project name and number, engineer's name, and date. Additional manual annotation shall be provided, if necessary, to adequately cross-reference computer printouts, so that a third party can review the calculations without requiring additional information.

1.9.3 LOADS

Structures and their elements shall be designed for the loads prescribed in these criteria unless applicable codes or ordinances provide more stringent requirements. The most stringent requirement shall be used.

1.9.3.1 DEAD LOADS

Dead loads are loads that remain permanently in place. They shall include the weights of all permanent materials and equipment (including the structure's own weight) supported in, or on, a structure. Load calculations shall include an allowance for any loadings that are anticipated to be added at a later date. Initially assumed loads shall be revised so that the final design reflects the configuration shown on the drawings.

- The minimum allowance for the weights of partitions, where partitions are likely to be rearranged or relocated, shall be as follows:
 - For partition weights of 150 pounds per linear foot (plf) or less, an equivalent uniform dead load may be used, determined on the basis of the room dimensions (normal to the partition) and the partition weight in pounds per linear foot, but not less than 20 pounds per square foot (psf).
 - For partition weights above 150 plf, the actual loads shall be used.
 - Partitions that are likely to be rearranged or relocated should be calculated as live loads for load factor design. A factor of 1.1 shall be applied to the live loads due to movable partitions before application of building code-required live-load factors.
- The unit weights of materials and construction assemblies for buildings and other structures shall be those given in American National Standards Institute (ANSI)/American Society of Civil Engineers (ASCE) Standard ANSI/ASCE Standard 7-88. Where unit weights are neither established in that standard nor determined by test or analysis, the weights shall be determined from data in the manufacturer's drawings or catalogs.
- Design dead loads shall include the weight of all permanent service equipment. Service equipment shall include plumbing stacks, piping, heating and air-conditioning equipment, electrical equipment, flues, fire sprinkler piping and valves, and similar fixed furnishings. The weight of service equipment that may be removed with change of occupancy of a given area shall be considered as live load.

1.9.3.2 LIVE LOADS

Live loads shall include all loads resulting from the occupancy and use of the structure whether acting vertically down, vertically up, or laterally. The weight of service equipment that may be removed with change of occupancy of a given area (e.g., fume hoods) shall be considered as live load. Operating, moving, stopping, and impact forces shall be considered part of the live loads. Live loads shall include neither dead loads nor loads from the environment, such as wind, tornado, earthquake, thermal forces, earth pressure, and fluid pressure.

- Live loads for buildings and other structures shall be those produced by the intended use or occupancy. In no case shall they be less than the minimum uniform load or concentrated load stipulated in ANSI/ASCE Standard 7-88, or required by the local building code, whichever is more stringent. A minimum of 60 psf of hanging load shall be included for any central energy plant or major mechanical room where significant hanging loads are anticipated.

- Live loads on roofs shall be as stipulated in ANSI/ASCE Standard 7-88, or as required by local building codes, whichever is more stringent. Live loads on roofs shall include the minimum roof live loads or the snow loads and snow drifts or possible rain loads stipulated in the code, whichever produces the more severe effect. An allowance of 10 psf shall be included in the design of all roofs to allow for one reroofing in the future.
- In continuous framing and cantilever construction, the design shall consider live load on all spans, as well as arrangements of partial live load that will produce maximum stresses in the supporting members.

1.9.3.3 SNOW LOADS

Snow loads shall be as calculated in compliance with the provisions of ANSI/ASCE Standard 7-88, or the requirements of local building codes, whichever is more stringent.

1.9.3.4 WIND LOADS

Wind load design for buildings and other structures shall be determined in accordance with the procedures in ANSI/ASCE Standard 7-88, or local codes, whichever is more stringent, by using the basic wind speed obtained by the procedures used.

- Exposure "C," as defined in ANSI/ASCE Standard 7-88, shall be used as a minimum for all construction unless it can be shown that the necessary permanent shielding will be provided by natural terrain (not including shielding from trees or adjacent buildings).
- To determine the design wind loads, all factors and coefficients stipulated in ANSI/ASCE Standard 7-88 shall be applied to the site-specific basic wind speeds.
- Building additions shall be designed as parts of a totally new building without regard to shielding from the original building and without regard to lesser wind resistance for which the original building may have been designed. The possibility that the original portion of the building may require strengthening because of an increase in the wind loads acting on it shall be considered.

1.9.3.5 SEISMIC LOADS

To comply with Executive Order 12699, Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction, seismic load design for buildings and other structures shall be determined in accordance with the recommendations of the Interagency Committee on Seismic Safety in Construction (ICSSC). Thus, the completed design for all new construction projects shall be submitted along with proper certification from a registered structural engineer that the design substantially meets or exceeds the seismic safety level in the *National Earthquake Hazard Reduction Program (NEHRP) Recommended Provisions for the Development of Seismic Regulations for New Buildings*.

- Each of the model codes listed below provides a level of seismic safety substantially equivalent to that provided by use of the *NEHRP Recommended Provisions*, with the requirement that revisions of these model codes must be affirmed to be substantially equivalent to or to exceed the then current or immediately preceding edition of the *NEHRP Recommended Provisions*, as it is updated triennially.
 - The Uniform Building Code, published by the International Conference of Building Officials (ICBO).
 - The National Building Code, published by the Building Officials and Code Administrators International (BOCA).
 - The Standard Building Code, published by the Southern Building Code Congress International (SBCCI).

Section 1 - General Planning and Design Data

- State, county, local, or other jurisdictional building ordinances adopting and enforcing these model codes in their entirety without significantly diluting seismic safety are also adequate. In all other circumstances, substantial equivalency of the ordinances to the seismic safety level contained in the *NEHRP Recommended Provisions* must be confirmed by a registered structural engineer.

1.9.3.6 OTHER LOADS

Other load requirements are as follows:

1.9.3.6.1 EQUIPMENT SUPPORTS

Equipment supports shall be designed to avoid resonance resulting from the harmony between the natural frequency of the structure and the operating frequency of reciprocating or rotating equipment (e.g., fume hood exhaust fans, vacuum pumps) supported on the structure. The operating frequency of supported equipment shall be determined from manufacturers' data before completion of structural design. Resonance shall be prevented by designing equipment isolation supports to reduce the dynamic transmission of the applied load to as low a level as can economically be achieved in the design.

1.9.3.6.2 FOUNDATION OR OTHER RETAINING STRUCTURES

Every foundation or other wall serving as a retaining structure shall be designed to resist, not only the vertical loads acting on it, but also the incident lateral earth pressures and surcharges, and the hydrostatic pressures corresponding to the maximum probable groundwater level.

1.9.3.6.3 RETAINING WALLS

Retaining walls shall be designed for the earth pressures and the potential groundwater levels producing the highest stresses and overturning moments. When a water-pressure-relief system is incorporated into the design, only earth pressures need be considered. In cohesive soils, the long-term consolidation effects on the stability of the walls shall be considered. Lateral earth pressures shall be determined in accordance with accepted structural and geotechnical engineering practice.

1.9.3.6.4 STRESSES AND MOVEMENTS

The design of structures shall include the effects of stresses and movements resulting from variations in temperature. The rise and fall in the temperature shall be determined for the localities in which the structures are to be built. Structures shall be designed for movements resulting from the maximum seasonal temperature change.

1.9.3.6.5 CREEP AND SHRINKAGE

Concrete and masonry structures shall be investigated for stresses and deformations induced by creep and shrinkage. For concrete and masonry structures, the minimum linear coefficient of shrinkage shall be assumed to be 0.0002 inch per inch, unless a detailed analysis indicates otherwise. The theoretical shrinkage displacement shall be computed as the product of the linear coefficient and the length of the member.

1.9.3.6.6 VIBRATION-SENSITIVE EQUIPMENT

The design professional shall be responsible for verifying the requirements of, and for, installation of vibration-sensitive equipment in all laboratory areas. The structural system in laboratory areas shall be designed to accommodate and control specific high localized frequency loads and vibration inputs from the general building systems to these sensitive areas. Five controls must be pursued:

- Use of physical separation to keep powerful sources of vibration well clear of the laboratory space.
- Identification and isolation of particular services that involve running speeds close to the natural frequencies of the floor.

- Identification and additional isolation of sources that, although they do not match the running speed of equipment and primary structural response frequencies, may produce sufficient vibration to cause a threat to the building.
- Identification, and, where possible, appropriate attenuation, of powerful transient impulses from services (e.g., switching in or out).
- Providing structural stiffness to reduce the peak acceleration responses caused by footfall-induced vibration.

1.9.3.7 LOAD COMBINATIONS

Combination of loads, allowable stresses, and strength requirements for buildings and incidental structures shall be as stipulated in the governing local building code.

1.9.4 STRUCTURAL SYSTEMS

The following paragraphs concern the basic supporting systems of buildings.

1.9.4.1 FOUNDATIONS

The provisions of the local governing building code shall be the minimum requirements for foundation design. The potential adverse effects of frost heave and movements due to expansive soils shall also be considered in the design. For all structures, the requirements of standard design criteria shall be met with respect to determining subsurface conditions, recommending foundation type, establishing allowable soil-bearing pressure, determining seismic potential, and differential settlement.

- Where concrete slab-on-grade construction is used, the slab shall be placed on a capillary water barrier overlying a compacted subgrade. A moisture retardant shall be used under the slab, where moisture conditions warrant. Excess loads, or equipment subject to vibration, shall be supported by separate pads isolated from the rest of the floor slab with flexible joints.

1.9.4.2 FRAMING SYSTEMS

Buildings shall be framed to allow for simple formwork, fabrication, and construction procedures. Structural systems shall be designed for ductile modes of failure to the extent feasible.

- In the selection of a framing system, consideration shall be given to the structure's functional requirements, including:
 - Column-free areas
 - Floor-to-ceiling heights
 - Number of stories
 - Elevator, escalator, crane, and hoist installations
 - Heavy loads
 - Other requirements pertaining to the specific facility.
- For framed floors, the economy of prefabricated systems shall be considered, especially systems that simplify the installation of mechanical, electrical, and communications services.

1.9.4.3 LATERAL LOAD-RESISTING SYSTEMS

Lateral load-resisting systems shall be provided to resist the effects of wind, earthquake motions, thermal forces, soil pressures, and dynamic forces caused by rotating, reciprocating, or moving equipment. Use systems recognized by the local building code. In the absence of local building code criteria, use structural systems recognized by the BOCA National Building Code for use in resisting seismic loads.

1.9.5 BUILDING MOVEMENT JOINTS

Devices, usually in the form of joints, shall be designed into buildings to control movement.

1.9.5.1 CONTROL JOINTS

Control joints shall be provided in all materials subject to drying shrinkage. Control joint size and spacing shall be based on a rational analysis.

1.9.5.2 EXPANSION JOINTS

Expansion joints shall be provided in all materials subject to thermal expansion. Expansion joint size shall be based on a rational analysis. In the absence of local building code requirements, building expansion joints shall be provided as recommended in the publication *Expansion Joints in Buildings* (Federal Construction Council of the Building Research Advisory Board).

1.9.5.3 SEISMIC JOINTS

When seismic design is required, building expansion joints shall be seismic type. Buildings shall be separated adequately to prevent contact during an earthquake that would damage the structural systems of the buildings.

1.10 Lease Administration

For a leased facility the following topics must be included in the Solicitation for Offers. The required information in this section shall be provided by EPA for each specific project. Contact the project officer for project information.

DEFINITION OF GROSS AREA NET USABLE SQUARE FEET

- General
- Square Feet
- Appurtenant Areas and Facilities

VENDING FACILITIES

JANITORIAL SERVICES

MAINTENANCE AND TESTING OF SYSTEMS

- General
- Testing
- Watertight Integrity
- Additional Requirements

FLAG DISPLAY

- General
- Display

SAFE AIR CONTAINMENT LEVELS

- General
- Asbestos
- Post-Asbestos-Abatement Monitoring
- Abatement Actions Other than Removal
- Nonfriable Asbestos
- Abatement Plan
- Inspection and Testing

1.10.1 OFFER REQUIREMENTS

HOW TO OFFER
OVERVIEW OF SERVICES
PHASES, TASKS, AND DELIVERABLES
OFFER DUE DATE
OCCUPANCY
TERM
NEGOTIATIONS
PRICE EVALUATION
AWARD
CONSTRUCTION
FIRE PROTECTION/OCCUPATIONAL HEALTH AND ENVIRONMENTAL SAFETY
HANDICAPPED AND SEISMIC SAFETY
ALTERNATE PROPOSALS
QUALIFICATION CRITERIA
EVALUATION FACTORS FOR AWARD

END OF SECTION 1

Section 2 - Site Work

2.1 Scope of Project

2.1.1 GENERAL

The location, type of building and support facility proposed, impact on site development, and general scope of work shall be described for the project. The description shall include such elements as access roads, parking areas, and loading and unloading areas.

2.1.2 DEVELOPMENT CODES

All projects must comply with the applicable zoning and building codes and with the requirements of the Americans with Disabilities Act (ADA). Information on applicable codes must be provided as stated in the following subsections.

2.1.2.1 ZONING

A brief overview of local zoning and land development codes and their impact on site development shall be given for the proposed project.

2.1.2.2 BUILDING CODES

Description of the applicable building codes shall be provided, with any specific references to seismic, floodplain, or coastal development as it relates to site development.

2.1.2.3 ADA REQUIREMENTS

The proposed project will comply with current federal (28 CFR Parts 35 and 36), state, and local ADA guidelines for the physically disabled.

2.2 Site Influences

2.2.1 LAND RESOURCES

Information shall be provided on the geography, geology, climate, and hydrology of the site areas.

2.2.1.1 SITE VICINITY

The geographic location of the project shall be described. Site location with respect to designated floodplains will be noted. EPA facilities shall not be located within the 100-year floodplain. Appropriate information on the local area economy, business, and industry shall also be provided.

2.2.1.2 PHYSIOGRAPHY AND GEOLOGY

A general description of known site geology and physiography shall be provided. Appropriate information shall be taken from the preliminary geotechnical investigation if this has been performed and is available when information is being gathered for this document. Site planning must consider seismic effects and the geological, foundation, and tsunami (seawave) hazards often associated with earthquakes. Probability with respect to severity and frequency of ground shaking varies from one geographic region to another; regions in which there are similar hazard factors are identified as seismic zones. Refer to the National Earthquake Hazards Reduction Program to determine the seismic zone in which the site is located. Site planning must avoid fault zones because damage caused by ruptures along a fault cannot be prevented by reasonable design and construction practices.

2.2.1.3 CLIMATOLOGY

The specific climatic conditions of the proposed site shall be described, especially precipitation and predominant wind directions and highest expected wind gust on the site. Where available, local precipitation data shall be used in lieu of regional data for specific site hydrologic modeling.

2.2.1.4 HYDROLOGY

A general description of site hydrology shall be provided. This description shall include data taken from the preliminary geotechnical investigation and the Soil Conservation Service soil survey. The following specific site information shall be assembled for use in the hydrologic modeling of the project:

- Geographic location.
- Precipitation frequency data.
- Drainage area.
- Soil and cover.
- Runoff distribution.
- Groundwater.
- Rainfall intensity-duration curves based on historic record should be developed and used for each locale. The design storm events shall be based on a study of precipitation frequency, runoff potential, and runoff distribution relative to the physical characteristics of the watershed. Where available, stream gauge data shall be used to estimate design flows in major channels. Where stream gauge data are inadequate or unavailable, rainfall information shall be taken from documented sources, such as National Oceanic and Atmospheric Administration/U.S. Weather Bureau Technical Paper No. 40. Design storm precipitation values taken from documented sources or derived by published engineering methodology shall be used to estimate design flood discharges.

2.2.2 TRANSPORTATION SYSTEMS

The transportation requirements of the project and the project's relationship to and effect on existing roadways shall be described.

2.2.2.1 AIR

A general description of project requirements for heliports or airfields shall be provided.

2.2.2.2 LAND

A general description of the proposed project and its location relative to existing roadways shall be provided. Development of the proposed facility and the impacts on the existing roadway system shall be addressed. This assessment shall include references to the traffic impact analysis if such an analysis is required for the project. For sites located in metropolitan areas with extensive public transportation systems, access to public transportation is desirable.

2.2.2.3 WATER

A general description of project requirements relative to boating shall be provided, including requirements for marinas, docking and/or storage facilities, seawalls and refueling facilities. Applicable permitting requirements of federal, state, and local agencies shall also be addressed.

2.2.3 ENVIRONMENTAL CONSIDERATIONS

The project's effects on air quality, water quality, and noise levels shall be addressed. This subsection also provides requirements related to environmental justice and community involvement.

2.2.3.1 AIR QUALITY

The impact of the proposed project on air quality shall be addressed. The assessment shall include all sources of air emissions and compliance with the requirements of federal, state, and local agencies.

2.2.3.2 WATER RESOURCES

The proposed project's impact on available water resources, including both ground and surface waters, shall be addressed.

2.2.3.3 NOISE POLLUTION

Any noise pollution that will be associated with the proposed project, its impact on surrounding development, and the project's compliance with applicable zoning and land development codes on noise pollution shall be addressed.

2.2.3.4 ENVIRONMENTAL JUSTICE

Environmental justice should be considered in selecting a location for a new EPA facility. Communities involved should be given the opportunity to participate in the selection of the site and in the identification of ways to reduce adverse environmental effects that negatively affect human health.

2.3 Site Investigation

2.3.1 SITE SURVEYS

The design professional shall be responsible for providing site investigations, land (metes and bounds) surveys, and an environmental assessment of the site. Site investigations, land surveys, and environmental assessments shall be performed by registered professional engineers and/or land surveyors, as applicable.

At a minimum, the survey(s) shall show legal property boundaries, easements, and legal restrictions, as well as all man-made and natural physical characteristics, utility service locations (temporary and permanent), horizontal and vertical controls, benchmarks, roadways, and parking areas. Land surveys should conform to the requirements of General Services Administration (GSA) document PBS-PQ280, as applicable.

The degree of accuracy of construction, control, property, and topographic surveys shall be consistent with the nature and importance of each survey. Where required by law (i.e., applicable state statutes), all control and property surveys at EPA sites shall be performed by, or under the supervision of, a professional land surveyor registered in the state in which the site is situated.

2.3.1.1 PRELIMINARY SUBSURFACE EXPLORATION

Preliminary subsurface exploration shall be performed by a registered geotechnical engineer. The registered geotechnical engineer shall supervise all required testing, review and analyze all data and samples, and submit a report. All tests shall be performed by independent testing laboratories. Subsurface investigations should conform to the requirements of GSA document PBS-PQ280, as applicable.

2.3.1.2 ENVIRONMENTAL ASSESSMENT

Design and environmental professionals selected by EPA will evaluate the effects that the additions and improvements will have on the local environment. Under the purview of the National Environmental Policy Act (NEPA), an environmental assessment (EA) may also be required, which will determine the need for an environmental impact statement (EIS). The EA should conform to EPA environmental assessment requirements, as applicable. The preparation of the environmental assessment, if required, may be included as a part of the professional services contract. See also Chapter 7, paragraph 9, of the *Safety Manual*.

2.3.1.3 OUTDOOR POLLUTANT SOURCES

The facility shall meet the indoor air quality requirements described in Appendix B of this document. To address these requirements, primary strategies for indoor air quality control, as listed in Appendix B, subsection B.1.1.2, shall be addressed. The first strategy for indoor air quality control is source control, which involves outdoor pollutant sources. The design professional must respond to the requirements established in Appendix B, subsection B.1.2.1.3, which includes a list of factors that must be considered.

2.3.2 SITE EVALUATION

Site elements must conform to the siting requirements noted in subsection 1.5, Facility Design and Layout, of this Manual and in Chapter 1, paragraph 9, of the *Safety Manual*.

2.3.2.1 PURPOSE OF STUDY

The ultimate purpose of the site evaluation is to provide EPA with sufficient pertinent data to allow a complete understanding of the physical assets and liabilities of the given project site.

2.3.2.2 SITE DATA COLLECTION

Using the information developed above and in other sources required by this document, the design professional shall consider planning and zoning criteria for the subject property. This consideration shall include the investigation of all potential site development regulations such as density limitations, building setbacks, building height, building coverage, buffer requirements, and other development guidelines set forth in any applicable campus, site, or facility master plan or elsewhere in this document.

- An on-site investigation and review shall be conducted, which shall include representatives of the client, the design professional, and the preconstruction testing and inspection company. A site representative shall verify land features indicated on the survey. Photographs shall be taken at various locations to provide a visual record to aid in the development of the site analysis drawings.

2.3.2.3 SITE RESOURCE INVENTORY AND ANALYSIS

A site resource inventory and analysis shall be prepared, which shall include investigation of soil information, identification of site vegetation, hydrology and drainage analysis, topographic and elevation analysis, and analysis of view corridors and other physical characteristics of the site. A “buildable area” plan shall be developed by compiling information from the various analysis drawings. This plan shall indicate the acres of land that are suitable for construction. The site inventory and analysis shall include, but shall not be limited to, the following:

- The site overview will include, but will not be limited to, location, parcel delineation and acreage, existing zoning, and adjoining land uses.
- Physical site characteristic analyses include, but are not limited to, slope analysis, elevation analysis, existing vegetation identification, hydrology analysis, geological and soils analysis, site analysis, buildable areas analysis, and analysis of prevailing winds.
- Utilities include, but are not limited to, stormwater drainage, potable water, sanitary sewer, electrical power and communications, and mechanical systems.

2.3.3 GEOTECHNICAL INVESTIGATION

For permanent structures, subsurface conditions shall be determined by means of borings or other methods that adequately disclose soil and groundwater conditions. Data obtained from previous subsurface investigations shall be used, along with any additional investigations at the location that are deemed necessary. Subsurface investigations shall be performed under the direction of a professional geotechnical engineer. In earthquake-prone areas, appropriate geological investigations shall be made to determine the contribution of the foundation (subsurface) to the earthquake loads imposed on the structure. These investigations shall include, but shall not be limited to, a recommendation of foundation type, determinations of allowable soil bearing capacity, and assessment of the possible effects of seismic activity on the soil mass. A settlement analysis under different design loads shall be performed where differential settlement may cause structural, architectural, or any other type of building damage.

2.3.3.1 TESTING AND SAMPLING METHODS

Testing and sampling shall comply with American Society for Testing and Materials (ASTM) standards, including ASTM D-1586, ASTM D-1587, and ASTM D-2113. Soil samples shall be taken below the existing grade and at each change in soil stratification or consistency. The depth of soil samples shall be determined by the geotechnical engineer after consultation with the project engineer on site-related design requirements.

2.3.3.2 TEST REPORTS

All data required by ASTM or the other standard test methods used shall be obtained, recorded in the field, and referenced to boring numbers. Soil shall be visually classified in the field logs in accordance with ASTM D-2488, but the classification for final logs shall be based on the field information, results of tests, and further inspection of samples in the laboratory by the geotechnical engineer preparing the report. At a minimum, the report shall:

- Include a chart illustrating the soil classification criteria and the terminology and symbols used in the boring logs.
- Identify the ASTM or other recognized standard sampling and test methods used.
- Provide a plot plan giving dimensioned locations of test borings.
- Provide vertical sections plotted showing (1) material encountered, (2) reference to known datum, (3) number of blows per linear foot (N value), and (4) groundwater level for all holes where groundwater is encountered. Data for groundwater shall include both the initial groundwater level and the static groundwater level. Groundwater levels must be recorded when initially encountered and after they have been allowed to stabilize.
- Note the location of strata containing organic materials, weak materials, or other inconsistencies that might affect engineering conclusions.
- Describe the existing surface conditions.
- Summarize the subsurface conditions.
- Provide pavement structural design data, including results of California bearing ratio tests or modulus of subgrade reaction tests.
- Provide a profile and/or topographic map of rock or other bearing stratum.
- Analyze the probable variations in elevations and movements of subsurface water due to seasonal influences.
- Report all laboratory determinations of soil properties, including shrinkage and expansion properties.

2.3.4 GROUNDWATER INVESTIGATION

A groundwater investigation shall be made before selection of a dewatering control system. The investigation shall examine the character of subsurface soils, groundwater conditions and quality, and the availability of an electric power source. The source of seepage shall be determined and the boundaries and seepage flow characteristics of geologic and soil formations at, and adjacent to, the site shall be analyzed in accordance with the mathematical, graphic, and electroanalogous methods discussed in Technical Manual 5-818-5, U.S. Army Corp of Engineers. Field reports identifying groundwater elevations and other relevant features should be provided to the construction contractor responsible for dewatering and groundwater investigation.

2.4 Site Development

2.4.1 SURVEYING

The following surveys must be conducted, and the following survey documentation provided, for each site.

2.4.1.1 GENERAL

Construction, control, property, and topographic surveys shall be coordinated with the appropriate EPA authority. Where feasible, surveying support available from EPA contractors shall be used. Survey field notes shall be legibly recorded on standard (8½-by-11-inch) field-note forms. Field notes and final plots of surveys shall be furnished to the appropriate EPA authority. Any boundary surveys and recorded maps shall be forwarded to the appropriate EPA authority.

The degree of accuracy of construction, control, property, and topographic surveys shall be consistent with the nature and importance of each survey. Where required by law (i.e., applicable state statutes), all control and property surveys at EPA sites shall be performed by, or under the supervision of, a professional land surveyor registered in the state in which the subject site is situated.

2.4.1.2 SURVEY CONTROL

The appropriate EPA authority shall be responsible for establishing, recording, and perpetuating primary on-site horizontal and vertical control monumentation. In addition, the appropriate EPA authority shall be responsible for correlating primary site-specific horizontal and vertical monumentation with that of other appropriate agencies. All surveying and mapping shall conform to the standards listed in Table 2.4.1.2, Survey Standards.

Table 2.4.1.2 Survey Standards

Survey Standard	Survey Type
TEC-1110-1-147	CORPS Construction
ETL-1110-1-150	Global Positioning System (GPS)/Dredging
EM-1110-1-1000	Photogrammetry
EM-1110-1-1001	Geodetic control
EM-1110-1-1002	Monumentation
EM-1110-1-1003	GPS control
EM-1110-1-1005	Topographic and field supervision and maintenance [FY-94]
EM-1110-1-1006	Land boundary [FY-95]
EM-1110-2-1003	Hydrographic survey
EM-1110-1-1807	Computer-aided drafting design (CADD) (volumes 1-4)

2.4.1.3 MONUMENTATION

Requirements with respect to monumentation are as follows.

2.4.1.3.1 TEMPORARY CONTROL

For temporary control monuments:

- Where the scope and complexity of the project warrants, the placement, number, and location of temporary horizontal and vertical control monuments in new development areas shall be coordinated with the existing system and approved.

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- A minimum of two intervisible control monuments shall be placed along, or adjacent to, right-of-way lines. These temporary control monuments shall be tied to an established grid. The surveyor who sets such monumentation shall submit legible notes, drawings, and reproducible documentation to the appropriate EPA authority. The location and construction of all temporary monuments in the immediate vicinity of new construction shall be indicated on the construction drawings.
- Temporary control monuments shall be 5/8-inch-diameter mild steel bars or 3/4-inch-diameter iron pipe with a minimum length of 2 feet or plastic hubs. These monuments shall be set flush with, or within 0.2 feet of, the ground surface. Manhole rims, markings chiseled in concrete, PK nails in asphalt, and lead and tack in bedrock shall be suitable as alternative temporary monumentation when approved.
- Three guard posts with reflective-paint striping shall be installed adjacent to temporary control monuments in high-traffic areas to prevent vehicular damage. Temporary control monuments shall be set in conformance with the accuracy standards of the U.S. Corps of Engineers.

2.4.1.3.2

PERMANENT CONTROL

For permanent control monuments:

- The placement, number, and location of permanent survey monuments for horizontal and vertical control shall be coordinated with, and approved by, the appropriate EPA authority. The location and description of the nearest permanent survey monument shall be provided on construction drawings. These monuments shall be tied to an established state plane coordinate system.
- Any surveyor who sets a permanent survey monument shall submit legible notes, sketches, or other reproducible documentation that shows the location of the new monument relative to the on-site horizontal and vertical control network, to the applicable state plane coordinate system, to the North American Datum (NAD) of 1983, and to the Navigable Ground Vertical Datum (NGVD) of 1929. The convergence, scale factor, and elevation at the monument shall also be shown.
- Permanent survey monuments shall be considered properly positioned and represented only after the appropriate EPA authority has approved all survey procedures and calculations and has verified conformance to the Corps of Engineers standards and specifications.
- Permanent survey monuments shall be identified as prescribed by Corps of Engineers standards.
- These identification numbers shall be documented within the survey field notes and shown on the design drawings and within related documents. Temporary point identification for permanent survey monuments may be assigned by the surveyor; however, permanent point identification shall only be assigned to such monuments by the appropriate EPA authority. Permanent survey monuments shall not be removed without prior authorization from the appropriate EPA authority.

2.4.1.3.3

BENCHMARKS

For benchmarks:

- A minimum of one permanent benchmark for vertical control shall be established in each new development area. A minimum of three benchmarks shall be established if there are no existing benchmarks within a 3-mile radius of each new development area. Elevations shall be referenced to the North American Vertical Datum (NAVD) of 1983 and to the NGVD of 1929. Level section misclosures between fixed benchmark elevations shall equal or exceed third-order accuracy, as defined in the Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks or the Corps of Engineers standards.

- Permanent benchmarks shall be identified in the same manner as permanent survey monuments. Permanent benchmarks shall not be removed without prior approval by the appropriate EPA authority. The location and description of all benchmarks in the immediate vicinity of new construction shall be indicated on the construction drawings.

2.4.1.3.4 UTILITY, ROADWAY, AND PARKING AREA SURVEYS

Surveys of utilities, roadways, and parking areas shall be conducted according to the following requirements:

- Coordinates and elevations shall be determined for utilities, roads, and parking areas at their principal points of definition. This information shall be provided on the construction drawings. The principal points of definition for utility systems shall be utility poles, obstructions, manholes, valve boxes, and other appurtenances for heating and cooling lines, sewers, and overhead and underground power and telephone systems.
- Principal points of definition for potable water, and natural gas, distribution systems shall be valve boxes, main line intersects, and fire hydrants.
- The principal points of definition for roads shall be roadway centerline intersects. Road alignment surveys shall include stationing, bearings, and curve information tied to these principal points of definition. Where applicable, the following information shall also be provided on the construction drawings:
 - Stations and deflection angles for each point of intersection.
 - Right-of-way lines and markers.
 - Spot elevations (centerline, edge of pavement, and at intersects) at maximum intervals of 100 feet.
 - Other improvements (e.g., drainage inlets, wheelchair ramps, fire hydrants, sidewalks, and curb and gutter).
 - Topographic features within project limits.
 - Elevation contours.
 - Overhead and underground utility crossings (plan and profile).
 - Roadway drainage crossings.
 - Location and description of underground utility witness markers.

2.4.1.3.5 UNDERGROUND UTILITIES

Where exact routes of underground utilities are not defined within record drawings, the appropriate EPA authority shall coordinate necessary electronic line detection and exploratory excavation activities. Such utilities shall be located by survey and documented on the construction drawings.

2.4.1.3.6 CONSTRUCTION STAKING

Construction staking for new EPA facilities shall comply with local standards and with practices approved by the appropriate EPA authority.

2.4.2 SITE PLANNING AND DESIGN

In the development of a site proposed for construction, it is necessary, at a minimum, to address, analyze, and assess all site-related issues outlined below and to comply with the requirements of Chapter 2, Site Planning and Landscape Design, GSA PBS-PQ100.1, as applicable.

2.4.2.1 IMPACT

The following issues are to be studied in assessing the impact of a project on a given site:

- On-site capacities of present and future utilities.

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- Existing buildings (discussion shall include any need for temporary facilities and services to these buildings).
- Existing site utilities (discussion shall include any need for utility relocation and shutdown).
- Existing traffic patterns and vehicles, including emergency and service vehicles.
- The need for traffic phasing and control-plan requirements.
- Existing parking structures and surface parking (discussion shall include any need for temporary parking areas and additional capacity).
- Need for an environmental impact statement.

2.4.2.2 DEVELOPMENT

The following issues must be taken into account in determining whether the proposed development is appropriate and compatible with its natural environment and surrounding community.

- Preserving surrounding neighborhoods and communities. Laboratory facilities shall be located in areas where local zoning permits; however, facilities should be no less than one-quarter mile from existing residential developments and shall be located in such a way that prevailing winds will not direct fumes exhausting from EPA stacks toward existing residential developments.
- Preserving the character of the site, to the maximum possible extent, by retaining natural features, such as ground forms, trees, and other natural vegetation.
- Using the existing site to best advantage by locating and orienting buildings so that they are compatible with natural site features.
- Developing functional relationships between site access points, parking lots, buildings, service areas, and all other project site elements.
- Providing for orderly future expansion of facilities by considering logical expansion of buildings, parking, and support services.
- Reviewing and assessing the impact of development with respect to any approved campus master plan and site infrastructure master plan.

2.4.2.3 DESIGN CONSIDERATIONS

The following issues must be considered in planning any EPA facility or site.

2.4.2.3.1 ENERGY CONSIDERATIONS

Sun angles, prevailing winds, existing topography, microclimatic conditions, and major wooded areas shall be carefully analyzed to contribute to a more energy-efficient solution. Energy conservation should be enhanced by careful consideration and evaluation of the orientation of buildings. Climate assets should be maximized and climate liabilities minimized

2.4.2.3.2 VIEWS

Proper orientation of facilities to capitalize on major vistas is strongly encouraged. Views into the site from major roadways should be carefully designed to be attractive and reflective of EPA's mission.

2.4.2.3.3 TOPOGRAPHY AND DRAINAGE

A design shall be provided that works with, and not against, the existing grades. Significant positive drainage away from any existing or new construction is a primary concern. The design shall preserve, as much as is practical, any major existing drainage patterns.

- The natural grades of the site should be used to develop multilevel entry points, if possible. Positive drainage away from all portions of the building is required.
- The location of the 100-year floodplain should be determined, and if this is present on the site, the boundaries should be delineated on all surveys and site plans.
- The impact of development on stormwater runoff must be assessed.

2.4.2.3.4 ADJACENT LAND USE

In siting a facility, consideration should be given to existing land uses or potential development nearby, because such land use may affect or restrict the facility design. Existing and proposed traffic patterns shall be considered in the design of site access and driveway locations.

2.4.2.3.5 NOISE, FUMES, AND ODORS

Adjacent land uses may contribute noise, fumes, and odors; these uses shall be considered in the site development process. Noise or odors may be severe enough to disqualify a site from consideration; therefore, a thorough analysis of neighboring facilities must be undertaken to ensure compatibility of the proposed facility with the existing adjacent land uses and environment.

2.4.2.3.6 VIBRATION

If there are adjacent land uses that produce vibrations that can be measured on a proposed site, the extent of the vibration and whether it will affect the proposed program shall be determined.

2.4.2.4 HISTORICAL AND ARCHAEOLOGICAL CONSIDERATIONS

All publicly available documents shall be reviewed for any on-site historical or archaeological information. Any public record indicating historically or archaeologically sensitive areas on-site must be reported to EPA before any design is initiated. Archaeologically and historically sensitive areas on-site must be completely avoided until, and after, a thorough investigation has been completed and findings documented that provide direction on whether the area(s) in question may be used or must be preserved for future exploration.

2.4.2.5 COMMUNITY ISSUES AND ENVIRONMENTAL JUSTICE

Environmental justice issues, as established by EPA, shall be addressed and the requirements of any required community review processes ascertained. A report shall be provided to EPA early in the design process and well before any community review is required on the project. All community reviews are over and above any EPA design review; reviews shall not be combined. Requirements of community review panels may include, but are not limited to, the following:

- Separate plans prepared to specifically highlight or emphasize that group's concern.
- Research and data collection to be used in generating special reports and in the environmental assessment.
- Presentation graphics for a formal submission or presentation during the review process.
- Documentation of the review and approval process, submission requirements, deadlines for each portion of the process, and the sequence that must be followed.

- Identification of the methodologies, research, and data needed to identify and evaluate populations at disproportionately high environmental or human health risks and to ensure that these needs are considered in developing any EPA facility.

2.4.3 FACILITY SITING

This subsection addresses facility siting issues and requirements.

2.4.3.1 GENERAL

A site development plan shall be used to locate new facilities on existing or new sites in order to ensure effective site utilization and avoid future conflicts between existing and new facilities.

- During facility siting, an environmental assessment shall be prepared before the initiation of a Government action that may significantly affect the environment.
- To the extent possible, facilities shall not be sited in floodplains or in areas subject to flash floods; facility siting shall minimize destruction, loss, or degradation of wetlands.
- In selecting sites for new facilities, the following conditions and requirements shall be considered:
 - Programmatic and operating efficiency.
 - Natural topographic and geologic conditions.
 - Existing cultural, historical, and archaeological resources.
 - Endemic plant and animal species.
 - Past use of site and existence of known Resource Conservation and Recovery Act (RCRA) and/or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites.
 - Special siting requirements for facilities containing, using, or processing hazardous materials.
 - Health, safety, and environmental protection requirements.
 - Indoor air quality impacts (e.g., presence of radon in foundation soils and contamination from other exterior sources, natural or man-made).
 - Hazardous operations and consequences of potential accidents in adjacent facilities.
 - Natural hazards, including seismic activity, wind, hurricane, tornado, flood, hail, volcanic ash, lightning, and snow.
 - Wave action within any natural or man-made body of water (in accordance with the Coastal Engineering Research Center [CERC] Shore Protection Manual).
 - Physical protection requirements, security, and safeguard requirements (e.g., patrol rooms, gates, security posts, and vehicle barriers).
 - Adequacy of existing or planned support and service facilities, including utilities, roads, and parking areas.
 - Interrelationships among facilities and facilities' aesthetic compatibility.
 - Energy conservation requirements.
 - Impact of site selections.

2.4.3.2 LABORATORY SITING

New laboratories, EPA owned and leased, should be sited in consideration of the following guidance.

- Guidance from *Criteria for Siting of Laboratory Facilities Based on Safety and Environmental Factors*, prepared for EPA by Johns Hopkins University, School of Hygiene and Public Health, Peter S. J. Lees and Morton Corn.
- Site acquisition methodology as prescribed in the Environmental Closure Process for EPA Laboratories chapter of the Safety, Health and Environmental Management Program Guidelines.
- Local zoning code.

- Indoor air quality criteria referenced in Chapter 7, paragraph 3.e, of the *Safety Manual*.
- Location shall be large enough to accommodate the laboratory building and outbuildings (hazardous materials building) with adequate setbacks meeting local requirements and RCRA requirements.
- Laboratories preferably shall be located in light industrial areas where there are provisions for containing accidental spills prior to discharge to the local stormwater system and in areas that have fully staffed emergency response personnel (fire and medical), including hazardous materials (HAZMAT) teams.
- Laboratories shall not be located in residential areas or in mixed-occupancy high rise locations.

2.4.3.3 BUILDING LOCATION

New buildings and building additions shall be located in accordance with the site development plan.

2.4.3.3.1 OPEN SPACE

Open space shall be provided between structures to accommodate site security, landscaping, and other environmental considerations. Sufficient access shall be provided around building exteriors to accommodate emergency vehicles, maintenance vehicles, and snow removal equipment. In cold climates, building entrances, stairs, and other pedestrian circulation features should not be placed along the north side of buildings or within shaded areas. Off-site drainage areas and the environmental impacts that proposed stormwater management practices will have on surrounding properties shall also be carefully reviewed.

2.4.3.3.2 CONDITIONS AND REQUIREMENTS

The following conditions and requirements shall be considered during site selection for new buildings:

- Architectural and functional compatibility with the environment
- Operation and service function relationships
- Natural topographic and geologic conditions
- Existing cultural and archaeological resources
- Historic sites
- Abandoned mines or wells and potential for subsidence
- Endemic plant and animal species
- Availability of existing utility services
- Building setback requirements
- Availability of existing road systems
- Traffic volume
- Refuse handling and loading zone requirements
- Adequacy for parking, future expansion, and other land use requirements
- Health, safety, and environmental protection requirements
- Physical protection requirements
- Security and safeguard requirements
- Energy conservation requirements
- Indoor air quality impacts (e.g., presence of radon in foundation soils)
- Impact of site selection
- Minimum fire separation between buildings (in accordance with National Fire Protection Association [NFPA] 80A).

2.4.3.4 HAZARD SEGREGATION

In general, occupancies posing different levels of risk shall be separated by fire-resistive construction. Areas shall be segregated as noted below and as required by local building codes and NFPA 101.

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2.4.3.4.1 PARKING STRUCTURES

The construction, protection, and control of hazards in parking structures shall comply with the requirements of NFPA 88A. Parking garages located within buildings that contain other occupancies shall be separated from the remainder of the building by construction that has a fire resistance of at least 2 hours. Entrances between garages and elevators shall be protected by a vestibule having a 1½-hour, Class B or higher fire door. Doorways between garages and stairs, building corridors, or other non-garage areas shall be protected by 1½-hour, Class B or higher fire doors. The garage ventilation system must be designed as a separate entity from the main building and from the occupied spaces, with the exhaust from the garage directed outside. No recirculation of air is allowed in garages. In garages located under buildings, elevator vestibules shall be positively pressurized to prevent garage vapors from entering the occupied areas.

2.4.4 SITE PREPARATION

Local topography shall be considered during project and facility design. New facilities shall be planned to fit the local topography and to require a minimum amount of grading. Design shall include provisions for erosion control and soil stabilization in ditches, fill slopes, embankments, and denuded areas, and restoration of areas disturbed by the project. Restoration shall be to original or improved conditions.

2.4.4.1 DESIGN CONSIDERATIONS

Site preparation design shall meet the following criteria:

- Vehicle parking, sidewalks, and road requirements shall comply with subsection 2.6 of this Manual
- Site drainage design shall comply with subsection 2.7 of this Manual
- Site power and lighting shall comply with Section 16, Electrical Requirements, of this Manual.
- Site security requirements shall be taken into account and provided for in accordance with criteria established by the appropriate EPA authority.

2.4.5 DEWATERING

The design, installation, and operation of dewatering systems for groundwater control shall be the responsibility of the construction contractor, unless otherwise stipulated in the contract. The groundwater investigation and the selection and design of a dewatering control system shall comply with TM 5-818-5. The design engineer shall determine whether the assistance of a qualified groundwater hydrologist shall be required.

2.4.6 SHORING AND UNDERPINNING

All shoring and underpinning shall comply with the safety requirements of CFR Part 1926, Subpart P. Remedial underpinning shall be performed where existing foundations are inadequate. Precautionary underpinning shall be performed where new construction adjacent to an existing structure requires deeper excavation. A structural engineer specializing in underpinning shall perform any underpinning design, which shall comply with the principles in Winterkorn and Fang, *Foundation Engineering Handbook*.

2.4.7 EARTHWORK

Earthwork includes excavation, filling, stabilizing, and compaction of earth at the site. Earthwork also includes the addition of borrow and the disposal of excavated material. The earthwork design shall incorporate the findings of the geotechnical report required by subsection 2.3.3 of this Manual.

2.4.8 WATERFRONT CONSTRUCTION

Waterfront construction includes seawalls, docks, marinas, and other ancillary boating facilities associated with coastal development. This type of construction for EPA facilities shall comply with applicable federal, state, and local standards and with practices approved by the appropriate EPA authority.

2.5 Landscaping and Site-Related Requirements

2.5.1 GENERAL

Landscape planning, design, and development must be integrated with building massing, design, and materials. The landscaping design process must coincide with the building design process to create a single design that integrates site and buildings(s). The use of durable exterior materials that enhance both the site landscaping and the building design and help to integrate the two design disciplines is strongly encouraged.

If the facility is to be a part of an existing campus or among other buildings in a master-planned development, the landscape design as well as the building design must be integrated with, and compatible with, the style(s) of the previously constructed permanent facilities on campus. The existing and developed site assets shall be used to full advantage. The existing physical features of the site and surrounding buildings shall be observed and documented.

- The landscaping of the site shall create an environmentally sensitive and aesthetically attractive design. The natural environment should blend with the proposed new construction.
- Landscaped courts and open spaces that are accessible to all staff are encouraged.
- Grass-covered areas away from public view shall be provided and equipped as outside eating and visiting areas (with picnic tables, benches, and landscape furnishings).
- The facility surroundings shall be landscaped with trees, shrubs, flowering plants, and grass in a way that will enhance the aesthetic character of the building(s) and hide or screen exposed equipment and building parts, features, or functions that, by their nature, are not aesthetically pleasant. Vegetation may be used to screen, or form a barrier to, particulate matter and to protect the building(s) from motor vehicle pollutant sources.
- The topography of the site around the building(s) shall slope away from the building(s) and away from neighboring building(s) to direct any water away from the new facility and from any neighboring building(s).
- Xeriscape design practices (use of vegetation requiring minimal watering) shall be used to minimize maintenance of the plantings.
- In general, low-maintenance landscape design and features shall be used.

2.5.2 PROFESSIONAL QUALIFICATIONS FOR SITE DESIGN

All site landscaping shall be designed by a registered landscape architect. This landscape architect must maintain his or her registration continuously and without break for at least the entire design and construction process and for the life of the design contract for the project.

- All site landscaping shall be installed and/or modified by a professional landscaper or professional gardener. All landscaping (plants and grass), except for annuals, if used, shall be guaranteed for 16 months after acceptance by EPA.
- All costs for the landscaping shall be anticipated in the final cost estimate. These costs shall be included in the overall costs of the project. Such costs shall include, but shall not be limited to, the following:
 - Retaining curbs and walls
 - Plantings and grasses
 - Exterior signage and graphics

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- Site furniture and furnishings
- Irrigation
- Site hardscape and special pavings
- Warranties and guarantees
- Exterior screens and barriers
- Specialty features incorporated into the design
- Maintenance guarantees
- Site lighting
- Site sculpture.

2.5.3 GENERAL SITE REQUIREMENTS

All landscaping and site amenities for the proposed development shall be in accordance with all applicable local, state, and federal codes and industry standards. Also, landscaping and site amenities shall comply with any master plan or campus design requirements and all construction requirements and standards. The more stringent requirements shall be used if a conflict exists.

2.5.3.1 EXISTING CONDITIONS

The landscape architect shall (1) preserve existing trees and undergrowth, where appropriate, for buffers; (2) review buffer requirements of the local community; and (3) use existing trees to the extent possible, since the larger size will provide greater immediate impact on-site.

2.5.3.2 PLANTINGS

Guidelines on plantings are as follows:

- Establish functional design criteria.
- Consider focal or entry area; design main entry area to produce an obvious sense of arrival at facility
- Create views or screen views as needed.
- Develop color and seasonal interest.
- Provide orientation (e.g., with respect to sun and wind) for facility and creation of shade.
- Consider ultimate size and scale relative to specific area or site size.
- Consider formal planting plan or informal, naturalistic plan.
- Avoid major plantings in areas where expansion is planned.
- Provide appropriate location of plantings relative to prevailing wind and sun.
- Break up large areas of pavement with landscape islands.
- Choose plants and design plantings to be tolerant of climate, weather conditions, rainfall, and other environmental conditions.
- Determine irrigation requirements.
- Determine maintenance requirements such as fertilization rates, soil acidity, and, if required, pruning and trimming needs.
- Coordinate plantings with location of signs, light standards, hydrants, underground utilities, and other man-made structures.
- Ensure that lawns slope to provide proper drainage (minimum 1 percent grade).
- Provide ground cover on severe slopes for aesthetic and maintenance considerations.
- Planting must be reviewed and approved by the appropriate EPA personnel.

2.5.3.3 SITE FURNITURE AND FURNISHINGS

Guidelines for choosing and locating site furniture and furnishings are as follows:

- Select furniture design to complement the building theme.
- Determine quantity and location of furniture.
- Establish function intended for seating and waiting areas, outdoor meeting areas, and eating areas.
- Determine flag pole heights, location, and quantity and integrate into the design.
- Locate fences and identify their style, color, and purpose.

- Integrate trash receptacles, cigarette urns, newspaper dispenser boxes, and mailboxes into the design.
- Include safety review of proposed surfaces, equipment, and layout of programmed recreational and playground equipment.

2.5.3.4 SITE LIGHTING

The following guidelines apply to site lighting:

- Design lighting to complement the architectural and land planning theme and to accord with any current master plan or campus requirements.
- Utilize energy-efficient and easily maintainable fixture types (the selection of lighting fixtures must consider long-term costs).
- Heights of lighting standards must be appropriate to the scale of the building and the area being lit.
- Provide lighting intensity that is commensurate with the use of the area and the health and safety of employees and other persons accessing the building during non-daylight hours.
- Control light with respect to adjacent property.

2.5.3.5 EXTERIOR SIGNAGE AND GRAPHICS

Considerations with respect to exterior signage are:

- Appropriate scale.
- Viewing angle and speed of observer.
- Appropriate color and letter style and clarity of message.
- Appropriate locations for signage, including intersections, parking lots, and entries.
- Design that complements the building style, accent color, or building color.
- Clear identification of functions: traffic direction, orientation, and general information.
- Coordination of building identification at site entries with that on the buildings themselves; identification should be strong, legible, and compatible with interior signage and graphics.
- Compliance with signage ordinances (such compliance is required).
- Providing special identification for the project, if required.
- Signage must be reviewed and approved by appropriate EPA personnel.
- Designing exterior signage to allow future removal and change without damage to existing exterior materials and to allow possible reuse of the signage after its removal and/or reuse of the lettering of the removed signage.

2.5.3.6 OUTSIDE SERVICE AND UTILITY AREAS

Many elements are necessary for the proper operation of a building. Some are visually undesirable and require proper planning for screening and buffering, which should be incorporated into the building design. The design professional is responsible for coordinating the work of all disciplines and for identifying all elements of the proposed project that will have a visual impact. The following are among the items that may require appropriate screening and buffering:

- Meters
- Vaults
- Transformers
- Dumpsters
- Compactor units
- Emergency generators
- High pressure gas cylinder storage and manifold systems
- Pressure reducers

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- Valves
- Pump hoses
- Outdoor storage areas
- Loading docks
- Mechanical equipment
- Compressors and cooling towers.

2.5.4 HARDSCAPE REQUIREMENTS

Hardscape (paving) and hardscape materials shall be integrated with the building and architectural planning and with landscaping design and concept. In general, materials that soften typical hardscape (paving) designs shall be used. Appropriate material usage shall be integrated with an understanding of project budget and public versus restricted access and use areas.

2.5.5 RECREATIONAL REQUIREMENTS

Recreational site requirements shall be reviewed with EPA on a project-by-project basis.

2.6 Vehicle and Pedestrian Movement

2.6.1 ACCESS AND CIRCULATION

Although visual and other aesthetic aspects of access to the project site, and thus to the project facilities, are critical, the primary access requirements involve fire and life safety. The most current version of the *Safety Manual* shall be reviewed for these guidelines. Either traffic data will be provided or a traffic impact analysis will be performed. Geometric design of all roads, streets, access drives, and parking areas shall also comply with American Association of State Highway and Transportation Officials (AASHTO) GDHS-84. Gradients for roads, streets, and access drives also shall comply with AASHTO GDHS-84. Road and street grade changes in excess of 1 percent shall be accomplished by means of vertical curves. The length of vertical curves shall be determined in accordance with AASHTO GDHS-84. Roadway centerline gradient profiles shall be shown for vertical control.

- Design and details of construction of flexible and rigid pavements shall comply with the local state highway department standards. Concrete valley gutters may be provided if swales with flexible pavements are necessary. Joint layout plans and details shall be provided for all rigid pavements. A thickened edge shall be used along edges of rigid pavement where future construction will occur.
- Signs, pavement markings, channelization, and other traffic control measures shall comply with the requirements of the U.S. Department of Transportation (DOT) *Manual of Uniform Traffic Control Devices*.

2.6.1.1 FIRE DEPARTMENT APPARATUS ACCESS

Public records must be reviewed for any codes, on-site and campus design requirements, ordinances, and local fire department requirements for all emergency requirements. Fire department access involves fire department apparatus and on-site fixed fire safety equipment (e.g., fire hydrants, fire loops, postindicator valves, automatic sprinkler and standpipe system connections), vehicular circulation, pedestrian circulation, and parking. The following minimum requirements shall be met:

- All new buildings shall have at least two sides readily accessible to fire department apparatus at all times.
- Fire lanes shall be provided for buildings that are set back more than 150 feet from a road or that exceed 30 feet in height and are set back more than 50 feet from a road.

- Fire lanes shall be at least 20 feet wide, and the road edge closest to the building shall be at least 10 feet from the building.
- The minimum roadway turning radius shall conform to a 48-foot semitrailer template.
- Fire lanes shall be constructed of an all-weather driving surface capable of supporting imposed loads of 25 tons. If appropriate for the area and climate, these lanes may consist of compacted earth with top soil and seed.
- Any dead-end road more than 300 feet long shall be provided with a turnaround at the closed end of at least 90 feet in diameter.
- Fire lanes and access areas for fire hydrants and automatic sprinkler or standpipe connections shall be clearly identified by painting the curbs yellow, with black lettering reading “NO PARKING - FIRE LANE” spaced at 40-foot intervals. In addition, signage carrying the same message shall be posted at 100-foot intervals along the restricted area.

2.6.1.2 VEHICULAR CIRCULATION

Vehicular circulation design shall comply with the following requirements and guidelines:

- Vehicular circulation shall be designed in accordance with industry standards, code requirements, and any overall campus master plan or facilities master plan philosophy in effect at the subject site. Circulation shall respect the pedestrian circulation environment of the campus and/or facilities and provide for safe movement of vehicles and pedestrians. Existing traffic studies shall be evaluated and coordinated in order to implement the best possible overall circulation system.
- Vehicular access to a new project shall be evaluated with respect to existing and planned site circulation and shall provide for clear separation of staff, visitor, service, and bus vehicular circulation.
- Adequate emergency vehicle access shall be provided to all points on the building periphery by use of proper grades, surface materials, clearances, and other design features.
- Entrances to the facility or campus shall be clearly marked and located so that access to each building, parking area, group of buildings, and service area is convenient and recognizable.
- The siting of new buildings shall take into account the requirements of future expansion, design of buildings, roads, and surface and structured parking.
- Site vehicular design shall provide adequate space for queuing at drop-offs and exit drives for visitors, buses, 18-wheel vehicles, taxis, and other vehicle types, keeping turning conflicts to a minimum and permitting proper service vehicle maneuvering and staging.
- Internal drive aisle widths and turning radii shall be designed to allow for the expected service and emergency vehicles.

2.6.2 PARKING AND LOADING FACILITIES

Parking areas should not be located in front of buildings or at visually prominent locations along routes of approach. Landscaping, grading, and location shall emphasize attractive features and de-emphasize or obscure undesirable features. Parking lots shall meet local governmental standards for circulation, layout, and safety. Handicapped parking allocations shall comply with ADA guidelines. Perimeter concrete curbs and gutters shall be considered for all parking areas and access drives in built-up areas. In remote or little-used areas, concrete curbs and gutters shall be used only when required to control drainage. Removable

prefabricated concrete wheel stops may be used where appropriate. Specific parking design guidelines are presented in the following subsection.

2.6.2.1 PARKING DESIGN

Parking for the proposed development shall be based on applicable codes for occupancy, local zoning requirements, and any campus or facility master plan in effect at the subject site. As part of the site development phase, multilevel parking garages or below-ground parking shall be considered as an alternative to surface parking. At a minimum, the following guidelines shall be followed:

- Distribution of total parking (e.g., employee [by type], police, emergency vehicle, visitor, handicapped, motorcycle, bicycle) shall be calculated and clearly shown in the site development phase. The minimum size for standard passenger car stalls shall be 9 feet × 19 feet. Up to 15 percent of the parking may be designated for compact cars. Stalls for compact cars shall be at least 8 feet × 18 feet.
- The structural design for pavement on surface lots shall comply with local state highway department standards for general parking areas.
- Parking aisles and lots subject to frequent truck traffic shall be evaluated to determine whether thicker pavement sections are required.
- Design calculations shall provide for a potential growth in staff of 10 percent. Provision shall also be made for 25 percent expansion of the facility, with the design for future parking expansion shown.
- Parking areas must be clearly related to entry points. Walking distances should be kept to a minimum.
- Handicapped parking spaces shall be provided in accordance with ADA requirements or the requirements of state codes and ordinances if these are more restrictive.
- Sufficient slope (1 percent minimum) shall be provided for positive drainage for runoff.
- Slopes shall be no more than 4 percent.
- Sufficient open lawn area shall be allowed adjacent to parking lots for snow storage, as required by climate and area.
- Wherever possible, 90-degree parking design should be used.
- Surface drainage in parking areas must not cross designated pedestrian paths.
- Dead-end parking bays are not allowed.
- Existing large trees should be integrated into new parking areas, where feasible.
- Parking areas should provide curbs (consistent with site design) with a minimum 2-foot overhang behind the curb. Use of concrete wheel stops should be avoided.

2.6.3 PEDESTRIAN ACCESS

A functional system of walks connecting structures, operational areas, parking areas, streets, and other access paths shall be provided to meet the demands of pedestrian traffic. The location and width of these areas and paths shall be determined in accordance with the site development plan. Walks subject to use by the physically disabled shall comply with current ADA guidelines. Specific guidelines for the design of pedestrian walkways are prescribed in the following subsection.

2.6.3.1 DESIGN OF PEDESTRIAN WALKWAYS

Pedestrian circulation shall be designed in accordance with industry standards, code requirements, and any overall campus master plan philosophy in effect at the subject site.

- Sidewalks shall follow accepted design standards.
- Pedestrian walks shall have a minimum of 1 percent cross pitch for drainage.
- The width of walks shall be a function of pedestrian traffic volumes determined by the master plan and/or by specific project requirements.
- Walks shall accommodate handicapped persons. Slopes, landings, and access points shall be in accordance with ADA requirements as well as with the most stringent applicable code or combination of codes applicable to the project.
- Crosswalks from parking and other buildings shall be clearly painted and properly assigned.
- Walkway paths shall be designed in response to the expected-origin/destination analysis of the site and its users.
- Drop curbs shall be used to provide transition for handicapped persons at crosswalks, drop-off zones, and ends of walkways.

2.6.4 AIRPORTS AND HELIPORTS

This subsection provides general guidelines for design of aviation facilities and indicates requirements and conditions that must be considered in designing and assessing such facilities.

2.6.4.1 GENERAL

Planning and design of aviation facilities and airspace clearances shall comply with Federal Aviation Administration (FAA) AC 150/5050-5. Planning and design of aviation facilities shall emphasize safety for all modes of aircraft operations. Aircraft installations require permanent unobstructed airspace, and facilities and equipment constructed to facilitate maintenance, ground handling, and flight operations.

- Landing and takeoff paths (traffic patterns) shall be oriented to avoid need for critical-facility overflights. Traffic patterns and altitudes shall be established and published to provide for aircraft approaches that are away from critical facilities.
- Heliports shall be sited, and traffic patterns established, so that normal operation does not require overflights of critical facilities. Heliports shall not be located closer to critical facilities than 2 times the dimension of the landing pad or 3 times the rotor diameter of the largest helicopter authorized to land at the heliport.

2.6.4.2 SITE CONSIDERATIONS

The following site conditions shall be taken into account in determining the adequacy of the aviation facility:

- Topography
- Vegetation and existing construction
- Weather elements
- Prevailing wind direction in summer and winter
- Soil conditions
- Flood hazards
- Natural and man-made obstructions

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- Adjacent land uses
- Availability of usable airspace
- Accessibility of usable roads
- Location of site utilities
- Accommodation of future expansion
- Aboveground utilities.

2.6.4.3 DESIGN CONSIDERATIONS

The layout of airfield facilities shall support operational efficiency and provide safe conditions for takeoff and landing operations and for ground handling of aircraft.

- Airfield safety clearances shall comply with the clearance criteria of FAA AC 150/5300. The critical-decision-point and emergency landing areas for the various aircraft using a facility shall be determined on the basis of the respective aircraft performance charts.
- All other applicable design elements shall conform to the most current FAA criteria.
- In accordance with FAA AC 150/5070-6A, airfield layout shall also consider:
 - Wind direction and velocity analyzed
 - A taxiway system
 - Parking aprons
 - Supporting facilities.

2.7 Stormwater Management

2.7.1 STREET DRAINAGE

Street drainage in developed areas shall be conveyed within the roadway cross section. Curb inlets shall be used to divert storm flows to surface and subsurface stormwater conveyance systems. Curb inlets shall not be located within curb returns or in areas of heavy pedestrian traffic. Pedestrian and cyclist safety shall be considered during selection of storm inlet grates. Curb gaps shall be used where roadside drainage swales exist. Wherever possible, curb openings with inlets located in grassed areas should be utilized in lieu of curb inlets.

In locations where uninterrupted vehicular access is essential to critical operational activities, roadway cross sections shall be designed to convey runoff from the 25-year, 6-hour storm so that one driving lane width (12 feet) is free of flowing or standing water. Lower classification roadways shall be designed to convey runoff from the 10-year, 6-hour storm. Stormwater management systems shall have sufficient capacity to ensure that runoff from the 100-year, 6-hour design storm will not exceed a depth of 10½ inches at any point within the street right-of-way or extend more than 2½ inches above the top of the curb in urban streets. Inverted crown roadway cross sections shall not be used unless approved by EPA.

2.7.2 WATERSHED DEVELOPMENT

Site development plans shall be developed with careful review of the impact the plan will have on the watershed. Appropriate stormwater management strategies shall be developed to minimize or eliminate adverse effects on existing and future development within the watershed.

2.7.3 EROSION AND SEDIMENTATION CONTROL

Erosion and sedimentation control measures, in accordance with federal, state, and local standards, should be used during construction. The site should be properly graded and planted to minimize erosion.

2.7.4 STORMWATER RETENTION AND DETENTION

Site development plans shall incorporate appropriate stormwater retention/detention facilities into the storm drainage system. These facilities must be designed in strict accordance with all applicable federal, state, and local requirements.

2.7.5 CONVEYANCE

Subsurface and open channel stormwater conveyance systems shall meet the following requirements.

2.7.5.1 STORM SEWERS

Subsurface drainage systems shall be sized to accommodate runoff from the 10-year, 6-hour storm and shall be sized for a greater storm in locations where there is substantial risk to critical facilities and operations. Subsurface system designs shall meet sediment transport requirements. Storm sewers shall be designed to maintain a minimum scour velocity of 2 feet per second. New storm sewers shall be sized for open channel flow. The minimum storm sewer size shall be 15 inches. The minimum culvert size shall be 15 inches. For roof drain systems, the minimum pipe size for laterals and collectors shall be 6 inches.

2.7.5.2 OPEN CHANNELS

Open channel stormwater conveyance systems shall be sized to accommodate the 10-year, 6-hour design flow with a minimum freeboard and shall be sized for a greater storm in locations where there is substantial risk to critical facilities and operations.

Open channel stormwater conveyance systems shall be designed for minimum maintenance. The potential for scour or deposition within earth-lined channels shall be considered before approval by the appropriate EPA authority. Preference for earth-lined or "armored" channels shall be based on a comparison of capital, maintenance, and operation costs. Inlets to open channel stormwater conveyance systems shall be placed at locations where erosion potential is minimal.

2.7.6 STORMWATER QUALITY

Site development shall incorporate quality control measures that reduce the concentration of pollutants in stormwater prior to discharge into receiving waters.

2.7.7 FLOODPLAIN AND WETLANDS DEVELOPMENT

Development, modification, or occupancy of floodplains and wetlands should be avoided, particularly when practical alternatives exist. To the extent possible, EPA shall meet the requirements of Executive Orders 11988 and 11990. EPA shall:

- Avoid, to the extent possible, the long-term and short-term adverse impacts associated with the destruction of wetlands and the occupancy and modification of floodplains and wetlands, and avoid direct and indirect support of floodplain and wetlands development wherever there is a practicable alternative for new development.
- Incorporate floodplain management goals and wetland protection considerations into its planning, regulation, and decision making.
- Carefully consider the potential impacts of any EPA action in a floodplain and the impacts of any new EPA construction in wetlands not located in a floodplain.
- Identify, consider, and, as appropriate, implement alternative actions to avoid or mitigate adverse impacts on floodplains and wetlands.
- Provide opportunity for early public review of any plans or proposals for actions in floodplains or new construction in wetlands.

- Ensure that construction within floodplains or wetlands complies with 10 CFR Part 1022 and NEPA and implementing regulations.

2.7.8 COASTAL DEVELOPMENT

The development of site boating, docking, and seawall facilities shall conform to all federal, state, and local requirements.

2.8 Utilities and Support Services

2.8.1 WATER DISTRIBUTION SYSTEMS

This subsection applies to water distribution systems for domestic (potable) and industrial (nonpotable) uses. The use of dual water systems (i.e., domestic and industrial or irrigation) is subject to the approval of the appropriate EPA facilities engineering group. Where use of dual water systems is approved, the location and alignment of such systems must be clearly identified by location markers placed throughout the site at intervals specified by the appropriate EPA facilities engineering group. Both systems must also be clearly identified on the record drawings.

- Cross connections between domestic and industrial or irrigation systems are prohibited. Domestic water conveyed within distribution systems that serve EPA facilities shall comply with the applicable Safe Drinking Water Act (SDWA) requirements; 40 CFR Parts 141–142; and all other applicable state, regional, and local requirements. The quality of domestic water within such distribution systems shall be protected from degradation by installation of reduced-pressure principal assembly backflow preventers to prevent backflow of contaminants or pollutants into the system.
- Backflow prevention devices shall be installed in accordance with the National Plumbing Code. Only devices approved by the Foundation for Cross-Connection Control and Hydraulic Research shall be used. (Refer to *Manual of Cross-Connection Control* [6th Edition, August 1979].)

2.8.1.1 PLANNING CONSIDERATIONS

The following considerations shall be incorporated into the project planning.

- During route selection and initial planning for water distribution systems, the following conditions and requirements shall be considered:
 - Projections concerning future population and development
 - Anticipated average daily flow for fully developed conditions
 - Anticipated peak flows for domestic, industrial, fire, and special water usage
 - Hydraulic design criteria
 - Health and safety requirements
 - Physical constraints (e.g., utility corridors and topographic features)
 - Energy conservation and environmental constraints.
- Distribution system layouts shall be as simple and direct as possible. Where feasible, initial planning efforts shall optimize system layouts (e.g., system loop lines) in order to:
 - Facilitate future system expansion
 - Strengthen fire protection capabilities
 - Minimize conflicts with other utilities
 - Reduce maintenance requirements.
- Water distribution systems shall be included within the utility master plan.

2.8.1.2 SYSTEM DESIGN CONSIDERATIONS

Domestic water distribution mains shall be sized to accommodate the greatest anticipated demand (e.g., fire demand, special requirements, or the peak domestic demand). Domestic water distribution systems shall be designed to deliver a peak domestic flow of 2½ times the average daily demand, plus any special demands, at a minimum residual pressure of 30 pounds per square inch (psi) at ground elevation (or higher pressure residual pressure if special conditions warrant).

- Domestic water distribution systems that also serve fire protection requirements shall be designed to satisfy fire flow requirements plus 50 percent of the average domestic requirements plus any industrial or process demands that cannot be reduced during a fire.
- Each fire hydrant within the distribution system must be capable of delivering 1,000 gallons per minute (gpm) at a minimum residual pressure of 20 psi. Where domestic water distribution systems must serve internal fire protection systems (i.e., sprinklers or foamite systems), adequate residual pressures shall be maintained for proper operation of these systems. Fire hydrant branches (from main to hydrant) shall be not less than 6 inches in diameter and shall be no longer than 300 feet. A gate valve shall be installed within each fire hydrant branch to facilitate maintenance. Fire hydrants shall be installed at maximum intervals of 400 feet and shall not be located more than 300 feet from the buildings to be protected. Each building shall be protected by at least two hydrants. All water mains supplying fire protection systems and fire hydrants shall be treated as fire mains and installed in accordance with NFPA 24. Water mains shall have a minimum pressure rating of 150 psi. Water distribution systems shall be designed to maintain normal operating pressures of 40 psi to 100 psi (at ground level) in mains and building service lines. Where the gradient across the service area is such that multiple pressure zones are necessary to maintain the normal operating pressures, pressure-reducing valves shall be used to separate each pressure zone. Use of pressure relief and surge relief valves shall be considered, as necessary, to preclude system damage from water hammer.
- Air release and vacuum breaker valves shall be installed, as required, at high points within the distribution system and in long supply mains.
- Distribution system mains shall have a minimum depth of cover of 3 feet. In cold climates, at roadway crossings in high traffic areas, and at railroad crossings, additional cover shall be provided to prevent freezing. Building service lines shall be at least 1 inch in diameter. Service lines that are less than 2 inches in diameter shall be connected to the distribution main by a corporation stop and a copper gooseneck, with a service stop below frostline. Service lines that are more than 2 inches in diameter shall be connected to the distribution main by a rigid connection and shall have a gate valve located below frostline. Risers from frostline to floorlines of buildings shall be adequately insulated. Water storage facilities shall comply with NFPA 22.
- Soil and groundwater conditions (e.g., soil corrosivity) on the site shall be considered in the selection of pipe materials. Where ferrous pipe is installed within the distribution system, insulating couplings shall be installed to prevent galvanic corrosion.

2.8.1.3 WELLHEAD DESIGN CONSIDERATIONS FOR RESEARCH PURPOSES

Where and when water must be provided for fish culture, on-site drilled wells shall be capable of producing a minimum of 20 gallons of water (of consistent quality) per minute unless otherwise required by the EPA project officer. The water must be of a suitable quality for rearing and maintaining fish cultures. It must not be contaminated with pesticides, heavy metals, sulfides, silica, or chlorides. The anions should be those found in natural lakes or streams. Water quality parameters should be as follows:

- Dissolved oxygen: > 6.0 milligrams per liter (mg/L)
- pH: 7.2–8.5
- Hardness: 40–200 mg/L (as CaCO₃)

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- Alkalinity: Slightly less than hardness
- Iron: < 1.0 mg/L
- Chlorides: < 250 mg/L as chlorides and sulfates
- Sulfides: < 2.0 micrograms per liter ($\mu\text{g/L}$) as undissociated H_2S .

The well and pump shall be protected from the elements. Two 500-gallon water tanks shall be installed as reservoirs for water prior to distribution.

2.8.2 WASTEWATER COLLECTION SYSTEMS

This subsection applies to sanitary wastewater collection systems (i.e., lift stations, force mains, collector sewers and interceptor sewers, and building sewers 5 feet beyond the building foundation).

2.8.2.1 SYSTEM DESIGN CONSIDERATIONS

Industrial wastewater and pollutants above the minimum concentrations specified by EPA shall be excluded from sanitary wastewater collection systems.

- Pretreatment systems (such as acid neutralization) shall be installed where required and shall meet EPA specifications.
- Hydraulic design of wastewater collection systems shall comply with TM 5-814-1, TM 5-814-2, and American Society of Civil Engineers (ASCE) 37. All wastewater collection systems shall be designed for gravity flow unless such systems are not economically feasible. Sewage lift stations and force mains shall not be used unless approved by the appropriate EPA authority. Feasibility analyses and economic evaluations of the costs of lift stations and force mains for construction, operation, and maintenance shall be prepared and submitted to the appropriate EPA authority for approval. Sewers and force mains shall be sized to accommodate the estimated daily maximum and minimum flow for the initial and final years of the design period. These maximum and minimum flows shall be specified by the appropriate EPA authority in accordance with ASCE 37.
 - Velocities in gravity sewers and force mains shall not exceed 10 feet per second.
 - Gravity sewers shall be designed for a minimum velocity of 2 feet per second.
 - Force mains shall be designed for a minimum velocity of 3½ feet per second.
- For the preliminary design, domestic water consumption rates shall be used to approximate wastewater flows. For the final design, where possible, actual flow data from an adjacent service area similar to the service area under consideration shall be used to estimate wastewater discharges. In the absence of such data, metered water use, less the consumptive use (i.e., water withdrawal rate), can be used.
- Sewers and force mains shall have a minimum depth of cover of 2 feet. Additional cover shall be provided to prevent freezing in cold climates and at roadway crossings. Sewer and force main trench widths shall be minimized; however, excavations, trenching, and shoring shall comply with 29 CFR Part 1926, Subpart P. Pipe bedding specified by the pipe manufacturer shall be in place before sewers and force mains are installed.
- Sewers or force mains shall not be routed within 50 feet (75 feet in pervious soils) of any well or reservoir that serves as a potable water supply. In all instances where such horizontal separation cannot be maintained, the sewer or force main shall be ductile iron pipe. Where groundwater is near the surface, special precautions shall be taken to prevent sewer infiltration or exfiltration. Where feasible, sewers or force mains shall not be routed within 10 feet of potable water lines or firelines.
- The horizontal distance between the water pipe and a sewer or force main shall not be less than 10 feet except where the bottom of the water line will be at least 12 inches above the top of the sewer pipe or force main, in which case the water pipe shall be laid at least 6 feet (horizontally) from the sewer or

force main. Where water pipes cross under gravity-flow sewer lines, the sewer pipe shall be fully encased in concrete for at least 10 feet each side of the crossing or, for this same distance, shall be made of pressure pipe, with no joint located within 3 feet horizontally of the crossing. Water lines shall, in all cases, cross above sewage force mains or inverted siphons and shall be at least 2 feet above the sewer main. Joints in the sewer main that are within 3 feet (horizontally) of the crossing shall be encased in concrete.

- Where feasible, sewers and force mains shall not be routed under buildings or other permanent structures. Sewers and force mains shall be adjacent and parallel to paved roadways. Sewers and force mains shall not pass beneath paved roadways except at roadway crossings. Where feasible, utility cuts within existing roadways shall be perpendicular to the roadway centerline to minimize trench length. Diagonal roadway cuts shall be avoided whenever possible.
- The selection of sewer and force main material shall be based on wastewater characteristics and soil conditions. Polyvinyl chloride (PVC) shall be considered where tree roots and infiltration are problems. Ductile iron pipe shall be used for force main and gravity sewer stream crossings. Ductile iron shall also be used for sewers located in parking lots and other high-traffic areas. Pipe joints shall have a watertight seal. Maximum infiltration-exfiltration test requirements shall be specified within the contract documents.

2.8.3 NATURAL GAS DISTRIBUTION SYSTEMS

Gas distribution shall comply with local codes and requirements. Fuel gas systems shall comply with NFPA 54. Liquefied petroleum gas systems shall comply with NFPA 58.

2.8.4 ELECTRICAL DISTRIBUTION SYSTEMS

Site power and lighting shall be coordinated as detailed in Section 16, Electrical Requirements, of this Manual.

2.8.5 TELECOMMUNICATIONS SYSTEMS

Site communications shall be coordinated as detailed in *EPA Structural Wire/Telecommunication Guidelines*.

2.8.6 SOLID WASTE COLLECTION SYSTEMS

Management of nonhazardous solid waste shall comply with 40 CFR Part 264 and with Subtitle D of RCRA. Management of hazardous waste shall comply with 40 CFR Part 264 and with Subtitle C of RCRA.

2.9 Reference Materials

2.9.1 GENERAL

All site work shall comply with all applicable federal, state, city, and local codes, regulations, ordinances, publications, and manuals. When codes and/or regulations conflict, the most stringent standard shall govern.

2.9.2 SOURCES

Refer to Appendix A for some of the many codes, regulations, trade organizations, publications, and guides that may be applicable.

END OF SECTION 2

Section 3 - Concrete

3.1 General Requirements

3.1.1 DESIGN AND CONSTRUCTION

This section covers the design and construction of plain, reinforced, and prestressed concrete structures, whether of cast-in-place or precast concrete construction. The use of recycled materials in cast-in-place and precast applications is encouraged, to the extent permitted by local and applicable technical codes. The requirements of this section shall be used in conjunction with the structural design activities.

3.1.2 CODES

Concrete materials, design, and construction for buildings and other structures shall comply with American Concrete Institute (ACI) 318 and local building codes.

3.1.3 USE OF COAL FLY ASH IN CONCRETE

Basic guidelines for using coal fly ash in concrete are contained in ACI 211.1.

3.2 Concrete Formwork

Formwork for concrete construction shall comply with ACI 347, ACI SP-4, and local building codes.

3.3 Concrete Reinforcement

3.3.1 REINFORCEMENT MATERIALS

Reinforcement materials for buildings and other incidental structures shall comply with local building codes and ACI 318.

3.3.2 REINFORCEMENT DETAILS

Reinforcement details shall comply with ACI 352R, ACI SP-66, ACI 318, and local building codes.

3.4 Cast-In-Place Concrete

3.4.1 GENERAL

This subsection covers the selection of materials; proportioning of mixes; and mixing, placing, testing, and quality control of cast-in-place concrete.

3.4.2 MATERIALS, TESTING, AND QUALITY CONTROL

Materials, testing, and quality control shall comply with ACI 318 and local building codes. Recycled materials shall be used to the extent permitted by codes.

3.4.3 TOLERANCES

Tolerances shall be as recommended in ACI 347.

3.4.4 SELECTING PROPORTIONS FOR CONCRETE MIXES

The proportions for concrete mixes of normal-weight concrete shall comply with ACI 211.1. The proportions for structural lightweight concrete shall comply with ACI 211.2.

3.4.5 MIXING, TRANSPORTING, AND PLACING

Mixing, transporting, and placing shall comply with the recommendations of ACI 304.

3.4.6 CLIMATIC CONSIDERATIONS

Hot-weather concreting shall comply with the recommendations of ACI 305R. Cold-weather concreting shall comply with the recommendations of ACI 306R.

3.4.7 POST-TENSIONED CONCRETE

In addition to the standards and resources referenced in other subsections, the Post-Tensioning Institute (PTI) *Post-Tensioning Manual* may be used for the design and construction of post-tensioned concrete structures.

3.5 Precast/Prestressed Concrete**3.5.1 STRUCTURAL**

This subsection covers materials, design, and construction of precast, precast and prestressed, and precast and post-tensioned structures. In addition to meeting the requirements of other subsections, precast concrete shall comply with the Precast Concrete Institute Manual (PCI MNL)-116. PCI MNL-120 and the PTI *Post-Tensioning Manual* may also be used as guides for the design and construction of precast concrete structures.

3.5.2 ARCHITECTURAL

This subsection covers materials, design, and construction of architectural precast, and architectural precast and prestressed, concrete members. In addition to meeting the requirements of other subsections, architectural precast members shall comply with the PCI MNL-117.

3.6 Cementitious Decks for Buildings**3.6.1 GENERAL**

This subsection covers materials, design, and construction of cementitious decks for building structures and prefabricated floor and roof systems such as:

- Lightweight precast reinforced concrete planks
- Lightweight precast reinforced concrete channel slabs
- Reinforced gypsum planks
- Structural cement-fiber roof deck systems
- Reinforced poured-gypsum-over-formboard roof systems.

3.6.2 MATERIALS, DESIGN, AND CONSTRUCTION

The materials, design, and construction of cementitious decks for buildings shall comply with the requirements of local building codes and the manufacturer's recommendations. In the event of a conflict between the local building code and the manufacturer's recommendations, the more stringent shall apply.

3.7 Repair and Restoration of Concrete Structures

This subsection covers the evaluation of damage or deterioration, selection of repair methods, surface preparation, and repair and restoration of concrete structures. The materials covered are portland cement mortars and concretes, latex-modified portland cement mortar, epoxy mortars, epoxy concrete, and methyl methacrylate concrete. Methods, procedures, and materials for the repair and restoration of concrete structures shall comply with guidelines ACI 503.4 and ACI 546.1R.

3.8 Concrete Inspection and Testing

Inspection and testing shall comply with the requirements of local building codes and ACI 318.

END OF SECTION 3

Section 4 - Masonry

4.1 General Requirements

4.1.1 DESIGN AND CONSTRUCTION

This section covers the design and construction of masonry structures. It shall apply to unit masonry construction; reinforced and unreinforced masonry structures; structures using cement, clay, and stone products; and those including brick, block, and tile structures. The requirements of this subsection shall be used in conjunction with those in other sections and subsections.

4.1.2 CODES AND SPECIFICATIONS

Materials, design, and construction of masonry structures shall comply with the requirements of local building codes. Recycled materials shall be used to the extent practical and allowed by code. The following sources may also be used as guides for the design of masonry structures:

- American Concrete Institute (ACI) 531
- ACI 531.1
- National Concrete Masonry Association (NCMA) TR 75B
- Brick Institute of America (BIA) Building Code Requirements for Engineered Brick Masonry.

4.2 Mortar and Grout

4.2.1 GENERAL

Requirements for materials, mixing, strength, and specifications for mortar and grout used in masonry structures shall comply with local building codes.

4.2.2 MORTAR

Mortar shall be designed to perform the following functions:

- Join masonry units into an integral structure.
- Create tight seals between masonry units to prevent the entry of air and moisture.
- Bond with steel joint reinforcement, metal ties, and anchor bolts, where used, so that they act integrally with the masonry.
- Give exposed masonry surfaces a desired architectural quality through color contrasts or shadow line from various joint-tooling procedures.
- Compensate for size variations in the units by providing a bed to accommodate the different unit sizes.

4.2.3 GROUT

Grout shall be used in reinforced load-bearing masonry construction to bond the masonry units and the reinforcing steel so that they act together to resist the imposed loads. It may also be used in unreinforced load-bearing masonry construction to give it added strength.

4.3 Unit Masonry

Materials, design, and construction of masonry units shall be in accordance with the requirements in subsection 4.1, General Requirements.

4.4 Masonry Accessories

Joint reinforcement, anchors, ties, and wire fabric shall comply with the following:

- Local building codes
- ACI 530.1.

4.5 Reinforced Masonry

Design and construction of reinforced masonry shall comply with the following:

- Local building codes
- ACI 530
- ACI 530.1.

4.6 Masonry Inspection and Testing

Inspection and testing of unit masonry, grout, mortar reinforcing, and accessories shall comply with the following:

- Local building codes
- ACI 530.1.

END OF SECTION 4

Section 5 - Metals

5.1 General Requirements

This section covers the design and construction of steel and aluminum structures. The requirements of this section shall be used in conjunction with those of other sections.

5.2 Structural Steel

Structural steel for buildings and other incidental structures shall comply with the following:

- Local building codes
- American Institute of Steel Construction, Inc., (AISC) M016 or M015L.

5.3 Steel Joists

5.3.1 CODES AND SPECIFICATIONS

Steel joists and joist girders shall comply with the following:

- Local building codes
- Steel Joist Institute's *Standard Specifications: Load Tables and Weight Tables for Steel Joists and Joist Girders*.

5.3.2 INTENDED USE

Steel joists shall not be used for wind bracing or other types of bracing. They shall be used only as horizontal load-carrying members supporting floor and roof decks.

5.3.3 SUPPORT OF VIBRATING EQUIPMENT

Steel joists shall not be used to support air-conditioning, air-handling, or any type of vibrating equipment. Steel joists serving as floor joists and roof purlins shall not have bracing members attached to them that would transmit vibrations from vibrating equipment into the steel joists and/or structural diaphragms.

5.4 Steel Decks

Steel decks shall comply with the following:

- Local building codes
- Steel Deck Institute Publication 20
- Steel Deck Institute Publication DDM01.

5.5 Miscellaneous Metals

5.5.1 DEFINITION

Miscellaneous metals are all ferrous and nonferrous metals other than structural steel as defined in the AISC Code of Standard Practice.

5.5.2 CODES AND SPECIFICATIONS

Miscellaneous metals shall comply with the requirements of local orders and with all applicable industry standards for the specific type of metal and use, as listed elsewhere in this section.

5.6 Light-Gauge Steel

Light-gauge steel shall comply with the following:

- Local building codes
- American Iron and Steel Institute (AISI) Specification for the Design of Cold-Formed Steel Structural Members.

5.7 Preengineered Metal Buildings**5.7.1 CODES AND SPECIFICATIONS**

Preengineered metal buildings shall comply with:

- Local building codes
- The Metal Building Manufacturers Association *Metal Building Systems Manual*.

5.7.2 LOADS

Where the use of the design loads specified in these design criteria would prevent procurement of preengineered metal buildings, consideration may be given to deviating from said loadings. Such considerations shall be based on an evaluation of whether such deviations would jeopardize personnel and/or material safety, a review of the type of occupancy and functional requirements of the particular building, and a determination of whether such deviation could be considered justified and permissible in accordance with local building codes.

5.8 Structural Steel Inspection and Testing

Structural steel inspection shall be as required by:

- Local building codes
- AISC *Manual of Steel Construction*.

END OF SECTION 5

Section 6 - Wood and Plastics

6.1 General Requirements

This section covers the use of wood and plastic materials in construction. The use of recycled materials in compliance with local and industry codes is encouraged. The requirements of this section shall be used in conjunction with the requirements of other sections in this Manual.

6.2 Partitions

Partitions requiring fire-resistance ratings shall be constructed of noncombustible/limited combustible (NC/LC) materials and either listed by Underwriters Laboratories Inc. (UL) or approved by Factory Mutual (FM) and listed in its approval guide. Refer to the description of off-gassing in Chapter 4, paragraph 3.b, of the *Safety Manual* for more information on indoor material requirements.

6.2.1 CEILING-HIGH PARTITIONS

As restricted by subsection 6.2, all ceiling-high partitions shall be constructed of NC/LC material. Interior finish or trim may be combustible to the extent permitted by the description in the interior finish discussion in Section 9, Finishes, of this Manual. Combustible insulation on electrical installations may be used to the extent described in Section 16, Electrical Requirements, of this Manual.

6.2.2 WOOD STUD PARTITIONS

Wood studs shall not be installed as part of new construction or as part of a major alteration or space adjustment in other types of construction.

6.2.3 LESS-THAN-CEILING-HIGH PARTITIONS

Bank type partitions, acoustical screens, freestanding space dividers, and other partitions that do not reach the ceiling shall conform to the requirements for movable partitions set forth by the General Services Administration (GSA) in PBS-PQ100.1. In addition, the placement of partitions relative to sprinklers shall comply with National Fire Protection Association (NFPA) 13, and adequate passageway width and identification of means of egress shall comply with NFPA 101. Another factor limiting the height and location of partitions is that tall or massive partition systems may interfere with the even distribution of conditioned air. Consideration should be given to the location of supply diffusers and return registers; the location of thermostats; and the clearance above, below, and around the partitions to allow adequate air circulation.

6.3 Use of Wood and Plastic

Laboratory shelving and casework may be fabricated using wood (plywood) and plastic materials. See subsection 10.5 of this Manual for requirements.

END OF SECTION 6

Section 7 - Thermal and Moisture Requirements

7.1 General Requirements

In selecting building materials, careful consideration shall be given to all technical criteria. Vapor barriers to vapor flow through the walls and roofs shall be placed with the aim of preventing moisture accumulation and condensation within the building structure, reduction of thermal performance, and increased latent cooling load in the space.

7.2 Design Characteristics

Design characteristics of exterior wall sections should be evaluated for functional and cost effectiveness in relation to the following:

- Moisture transport
- Thermal performance
- Weathertight design, including sealant profiles, material adjacencies, and flashing configuration.

7.3 Thermal Resistance

For information on the thermal characteristics of single materials or wall assemblies, refer to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *Handbook of Fundamentals* or the manufacturer's certified technical information. Thermal resistance (R) values shall be identified for each element in the building shell. "U" factor calculations are prepared by following the recommended procedures as documented in the ASHRAE *Handbook of Fundamentals*.

7.4 Moisture Transport

Dew point calculations are prepared by following the recommended design procedures in the ASHRAE *Handbook of Fundamentals*. The exterior envelope will be designed to prevent condensation within wall cavities, building spaces, etc.

7.5 Panel, Curtain, and Spandrel Walls

Openings between panel, curtain, and spandrel walls and the building structure or floor slabs around them, shall be fire stopped in accordance with the provisions outlined in Section 13, Special Construction, of this Manual. The requirements in this subsection in no way reduce the requirements for protection of walls subject to an exterior fire exposure. See Chapter 3, paragraph 8, of the *Safety Manual* for information on exposure protection.

7.5.1 PANEL AND CURTAIN WALLS

All panel and curtain walls shall conform to the requirements for nonbearing walls for the type of construction and model code involved and shall be securely anchored to the building in a manner that will prevent failure of the anchors in a fire or failure of the panel and its components in high wind.

7.5.2 SPANDREL WALLS

Except as noted below, spandrel walls shall be provided at each floor and shall have a height of at least 3 feet above the finished floor and a fire resistance equivalent to the floor involved.

7.5.2.1 EXCEPTION NO. 1

Exterior spandrel walls are not necessary and, if provided, are not required to have any fire resistance if the rooms located directly inside the exterior wall of the building and on the floor below contain low-hazard occupancies or occupancies that are sprinkler protected.

7.5.2.2 EXCEPTION NO. 2.

Spandrel walls are not required at grade level.

END OF SECTION 7

Section 8 - Doors and Windows

8.1 Doors

8.1.1 GENERAL

Unless otherwise noted, all doors shall be 36 inches wide. Doors in designed egress ways shall swing in the direction of egress. Doors shall not swing into exit ways in a manner that reduces the effective exit width.

8.1.1.1 HARDWARE

All doors shall be equipped with heavy-duty hardware. Each leaf (up to 80 inches high) shall be provided with minimum 1½ pair butt hinges or 2 pair butt hinges on doors higher than 80 inches. All doors shall have floor stops or wall bumpers. Exterior, egress, and laboratory doors shall have automatic closers. All public-use doors must be equipped with push plates, pull bars or handles, and automatic door closers. Corridor and outside doors must be equipped with cylinder locks and door checks. All locks must be master-keyed. The Government must be furnished with at least two master keys and two keys for each lock. Hardware for doors in the means of egress shall conform to National Fire Protection Association (NFPA) standard 101.

8.1.1.2 ENVIRONMENTAL CONSIDERATIONS

Doors, windows, and hardware exposed to highly corrosive conditions, as in marine or very humid environments, shall be nonferrous or provided with a protective, corrosion-resistant finish.

8.1.2 EXTERIOR DOORS

Exterior doors shall be weathertight and equipped with an automatic door closer, shall open outward, and shall have a drip rain diverter mounted above the door to channel water to the exterior wall. The force of the door closer shall comply with requirements of the Americans with Disabilities Act (ADA).

8.1.3 INTERIOR DOORS

Interior doors must have a minimum opening of 36 inches (width) by 80 inches (height) and shall comply with ADA. Hollow-core wood doors are not acceptable. Hardware shall be ADA compliant. Doors shall be operable by a single effort and shall be provided with vision panels in accordance with all applicable code requirements. All requirements of ADA shall be incorporated.

8.1.3.1 LANDING AREAS

The landing areas for doors that open onto walkways, ramps, corridors, and other pedestrian paths shall be clear and level with a slope of no greater than 1:50; they shall extend at least 5 feet from the swing side of the door, 4 feet from the opposite side, and at least 1½ feet past the latch side (pull side) of the door and 1 foot past the latch side (push side).

8.1.4 FIRE DOORS

Fire doors shall conform to NFPA 80. Doors, hardware, and frames shall bear the label of Underwriters Laboratories, Inc.; Factory Mutual; or another approved laboratory testing organization, in accordance with American Society for Testing and Materials (ASTM) E-152. Glazing material shall not be allowed in fire doors with a 3-hour fire protection rating or in fire doors with a 1.5-hour fire protection rating that are used in locations with severe fire exposure potential (such as in a flammable-liquids storage room). The maximum area of glazing in a 1- or 1.5-hour door shall be 100 square inches (0.065 square meters) unless the area has been tested and meets the requirements of NFPA 80. The area of glazing in fire doors that have less than 1-hour fire-resistance ratings shall be limited to the maximum area tested. All glazing shall be wired glass or other glass approved for use in fire doors.

8.1.4.1 EXIT DOORS

Fire doors in exits or means of egress shall also conform to the requirements contained in Chapter 4, paragraph 4, of the *Safety Manual*. Fire doors in air-handling systems shall also conform to the requirements outlined in Section 15, Mechanical Requirements, of this Manual.

8.1.5 LABORATORY DOORS

Laboratory doors shall be 48 inches wide (36 inches wide for the active leaf and 12 inches wide for the inactive leaf) and 84 inches high to facilitate easy movement of equipment and carts. Laboratory doors must swing out and should be inserted in alcoves regardless of the corridor width. In general, large vision panels should be provided to allow easy and quick safety inspection of laboratory spaces. Hardware shall be ADA-compliant and shall provide various levels of access control as required; it will include both combination and key access locks. Areas where a high level of security will be required shall be provided with card-key access control.

8.2 Windows**8.2.1 GENERAL**

The use of natural but controlled daylighting should be maximized as part of a total energy conservation program. EPA values natural light and perceives it as part of an exemplary working environment as well as a potential source of energy savings. The building organization and design concept shall bring adequate natural light into personnel spaces. Window size, number, and location shall be determined on the basis of need for natural light and ventilation and of energy considerations. All exterior windows in heated or air-conditioned spaces shall use double-glazed, insulated, low E glass and thermal break sashes. All windows in laboratory rooms that may contain explosive materials shall be glazed with safety glass.

8.2.2 FIXED WINDOW SYSTEMS

Laboratory space shall have windows that are nonoperable (except with a key, where windows must be opened for cleaning purposes) in order to maintain temperature and humidity control and room pressurization relationships.

8.2.3 SAFETY OF STOREFRONT AND CURTAIN WALL SYSTEMS

Windows extending to within 18 inches of the floor and located at least 4 feet above grade shall be provided with a safety bar on the interior window approximately 3 feet above floor level. Off-street, ground-level windows and those accessible from fire escapes and adjacent roofs must have anti-intrusion alarm systems to deter forcible entry.

8.2.4 WINDOW HEIGHT

Wherever windows extend to within 36 inches of the finished floor and are at least 4 feet above grade, a suitable metal barrier shall be provided on the interior side, approximately 56 inches above floor level. (Perimeter heating and cooling units may form this barrier.) If the glass construction can withstand a horizontal force of 200 pounds or more and meets the requirements of 29 CFR §1910.23, 16 CFR Part 1201, and the local building code, no barriers are required. For windows in walls that must have a fire-resistance rating, see NFPA 80A and Chapter 2, paragraph 7, of the *Safety Manual*.

8.2.5 GLAZED PANELS IN INTERIOR PARTITIONS AND WALLS

Interior glazed panels must comply with the Consumer Products Safety Commission Safety Standard for Architectural Glazing Materials (16 CFR Part 1201). When glazing panels and windows are used in fire barrier walls, such use shall also meet the criteria set forth in the *Safety Manual*.

8.3 Sun Shading

8.3.1 GENERAL

The design professional shall be responsible for providing window coverings for interior and exterior windows where required by the room data sheets. All exterior windows shall be reviewed and considered for window coverings. Use of window coverings shall be considered even when such coverings are not required by the data sheet, when solar glare and heat gain should be controlled. Nonpermanent window coverings installed on the inside of windows are considered "interior finishes" and are discussed in subsection 9.6 of this Manual.

8.3.2 LABORATORY WINDOWS

Laboratory windows exposed to direct sunlight shall be shaded with permanent exterior shading devices that shade the window from direct sun.

END OF SECTION 8

Section 9 - Finishes

9.1 Interior Finishes

The required finishes for each room are specified in the room data sheets included in Appendix C. The following requirements apply to interior finishing.

9.1.1 TRIM AND INCIDENTAL FINISHES

Interior wall and ceiling finish that covers no more than 10 percent of the aggregate wall and ceiling area involved may be Class C material in accordance with National Fire Protection Association (NFPA) 101, Chapter 6.

9.1.2 FINAL FINISHING MATERIAL

Wallpaper, paint, veneer, and other thin finishing materials that are applied directly to the surface of walls and ceilings and are not more than 1/28-inch thick shall not be considered as interior finishes per NFPA 101, Chapter 6.

9.1.3 AIRSPACE

Whenever an airspace is located behind combustible material, the space shall be blocked so that no void extends more than 10 feet in any direction. For example, wood paneling applied to wood furring strips will meet the requirement if the distance between the furring strips is no more than 10 feet in both a horizontal and a vertical direction.

9.1.4 COMBUSTIBLE SUBSTANCES

Materials composed of basically combustible substances (e.g., wood, fiberboard) that have been treated with fire-retardant chemicals throughout the material (e.g., pressure impregnation), as opposed to surface treatment, may be used as interior finish subject to the following conditions: (1) the treated material shall be installed in full accordance with the manufacturer's instructions and (2) the treated material shall not be installed in any location where conditions exist that may reduce the effectiveness of the fire-retardant treatment (e.g., high humidity). Surface treatments may be used to reduce the risks associated with existing conditions, in accordance with Chapter 6 of NFPA 101. No material that will result in higher flame spread or smoke development ratings than those permitted in this Manual shall be used as an interior finish.

9.2 Wall Materials

Wall materials must be capable of withstanding washing with detergents and disinfectants. Materials selected shall be compatible with their intended use and shall emphasize durability and low maintenance while creating a comfortable work environment.

9.2.1 LEAD-BASED PAINT

Lead-based paint shall not be used in EPA facilities per subsection 1.5.9.3.2 of this Manual. Refer to Chapter 4, paragraph 3.a, of the *Safety Manual* for restrictions on the use of lead-based paint.

9.2.2 WALL FINISHES

In general, walls shall be gypsum wallboard, with a painted finish, on metal studs. Walls in laboratory areas will be required to support additional loads due to movable casework, mounting rails, upper cabinets or adjustable shelves, and equipment anchorage. Therefore, structural wall studs, backing plates, and lateral bracing sufficient to withstand heavy loads will be required. Where concrete masonry unit (CMU) block or poured concrete walls are used to meet other design requirements or constraints, they shall be furred with gypsum wallboard or covered with another appropriate finish.

9.2.3 WALL COVERING AND FINISHES

Wall coverings and finishes, and the process by which they are selected, must meet the requirements outlined in the following subsections.

9.2.3.1 GENERAL

The required finishes must be designated for each room in the room data sheets, a copy of which is included with this document. Actual material selection, color, texture, etc., is left to the design professionals who shall make selections in consultation with the users. Paint shall be carefully selected so as not to affect laboratory operations. The design professional must also select finish materials for items and areas not specifically designated in the room data sheets. These selections shall be submitted to the Government representative for final approval.

9.2.3.2 FLAME SPREAD AND SMOKE LIMITATIONS

Wall finishes on walls that are part of a means of egress must have an interior finish of Class A (flame spread 0-25, smoke developed 0-450). (Interior finish ratings are derived from American Society for Testing and Materials [ASTM] E-84 and NFPA 255.) For any existing construction that is not protected throughout by a sprinkler system meeting the Government's approval, wall finishes must have an interior finish of Class A (flame spread 0-25, smoke developed 0-450). All new construction for EPA shall be protected throughout by a sprinkler system meeting the Government's approval; in construction that is so protected, wall finishes in all areas, except those that are a part of the means of egress, may have an interior finish of Class B (flame spread 26-75, smoke developed 0-450), unless otherwise restricted by an applicable code. The most restrictive requirement shall govern. In sprinkler-protected exit accesses or passageways, the interior finish may be composed of materials with a Class B interior finish rating (flame spread 26-75, smoke developed 0-450). (See NFPA 101 and PBS-PQ100.1 as the sources of this requirement.)

9.2.3.3 WALL COVERING

Wall covering made of materials that are considered "environmentally friendly" shall be provided in the administrative and other office areas when required (none shall be provided in the laboratory areas). Such wall covering shall meet the following criteria:

- Construction: All material shall be of uniform color throughout. Colors and patterns shall be chosen and approved by EPA from standard manufacturer lines offered by the design professional.
- Maintenance properties: All wall covering shall be resistant to permanent stains and mildew and shall be capable of being cleaned with mild, nonabrasive cleaners.
- Fire hazard requirements: Each type of wall covering used will have a minimum interior finish of Class C (flame spread 76-200, smoke developed 0-450) when tested in accordance with ASTM E-84.
- Application: Application of all wall covering shall be in accordance with the manufacturer's recommendations.

9.3 Finished Ceilings

9.3.1 GENERAL

Ceilings shall be set at a minimum height of 9 feet 8 inches in laboratory zones both in general spaces and in laboratory spaces and at a minimum height of 8 feet in corridor and office spaces. Except in service areas, ceilings must have acoustical treatment acceptable to the contracting officer, a flame spread rating of 25 or less, and a smoke development rating of 450 or less (ASTM E-84). Protrusion of fixtures into traffic ways is not allowed. Refer to the *Safety Manual* for fire-resistance requirements for ceilings.

9.3.2 CEILINGS NOT ALONG EXIT PATH

Ceilings and interior finishes in areas that are not part of the normal exit route may have an interior finish of Class C (flame spread 76-200, smoke developed 0-450), unless an applicable code is more restrictive.

9.3.3 CEILINGS ALONG EXIT PATH

In sprinkler-protected exit ways or enclosed corridors leading to exits, ceilings and interior finishes may be composed of materials with an interior finish rating of Class B (flame spread 26-75, smoke developed 0-450), unless an applicable code is more restrictive. The most restrictive applicable code shall be used.

9.3.4 CEILING FINISHES

Where ceiling finishes are required, they will, in general, be suspended acoustical tile with recessed fluorescent lighting fixtures. Other ceiling finishes will be required in special rooms, as specified on the room data sheets. These finishes will include hard ceilings with sealed openings for clean analytical laboratories. Special consideration shall be given to the type of grid system and acoustical tile when the ceiling is in a moist area or in food service and other specialty areas.

9.3.5 OPEN CEILINGS

All areas above open ceilings shall be painted. The necessary coordination shall occur for all requirements regarding painting of exposed areas, including engineered systems that require color-coded painting or stenciling and general code-required stenciling of nomenclature defining the rating of fire walls.

9.4 Floor Treatments

9.4.1 GENERAL

Floor finishes shall be compatible with the intended use of the room and shall emphasize durability and low maintenance. Floors and floor coverings may be of any material normal to the intended use. Materials may be either combustible or noncombustible, including wood, asphalt tile, carpet, rugs, linoleum, concrete, and terrazzo. Interior floor finishes shall meet the interior finish requirements noted above. (See subsection 9.1.1 on page 9-1 for more information on interior finish requirements.) Materials must be smooth, nonabsorbent, skid-proof, and wear resistant. Laboratory flooring should resist the adverse effects of acids, solvents, and detergents. Materials must be monolithic or have a minimum number of joints. The base may be a 4-inch vinyl or rubber base or an integral-coved base where sheet vinyl flooring is used.

9.4.1.1 FIRE SAFETY

Interior floor finishes shall be in accordance with Chapter 6 of NFPA 101 and shall be tested in accordance with NFPA 253. Flooring materials used as wall sections or wall coverings shall comply with the fire safety characteristics described in Chapter 4, paragraph 13.c, of the *Safety Manual* for flame spread and smoke development. The flame spread and smoke development characteristics shall be determined through testing in the orientation in which the material is to be installed (NFPA 253 results shall not be used to evaluate flooring tested in the vertical position).

9.4.2 CARPET

Carpet tiles shall cover all office floors and must meet the static buildup and flammability requirements that follow.

9.4.2.1 SPECIFICATIONS

The following specifications must be met for all new carpet installation:

- Pile yarn content: Continuous filament soil-hiding nylon or wool/nylon combinations.
- Carpet pile construction: Level loop, textured loop, level cut pile, or level cut/uncut pile.

- Pile weight: Minimum of 28 ounces per square yard.
- Secondary back: Synthetic fiber or jute for glue-down installation.
- Total weight: Minimum of 64 ounces per square yard.
- Flammability: In all areas except exits, carpet must have a critical radiant flux (CRF) of 0.25 or greater, with a specific optical density not higher than 450. Carpet in exits must have a CRF of at least 0.50. Carpet passing the Consumer Products Safety Commission FFL-70 (Pill Test) is acceptable for office areas; it may also be used in corridors that are protected by automatic sprinklers. Check applicable codes for any more restrictive requirements. The most restrictive requirement shall apply.
- Static buildup: 3.5 kilovolts (kV) maximum with built-in static dissipation is recommended; static-controlled is acceptable. More restrictive levels shall be required in sensitive areas such as computer rooms; these levels shall be determined by calculations for any special equipment in use.
- Interior finish requirements: As required by NFPA 101, Section 6-5.

9.4.2.2 COLOR

For new carpet, the Government shall be provided with at least three color samples. The sample and color must be approved by EPA prior to installation. No substitutes may be made after sample selection.

9.4.2.3 INSTALLATION

Carpet must be installed in accordance with the manufacturer's instructions.

- In leased space, carpet shall be replaced at least once every 7 years during Government occupancy, or whenever backing or underlayment is exposed and/or there are noticeable variations in surface color or texture, whichever occurs first.
- Carpet replacement shall include the moving and returning-in-place of all furniture. Floor perimeters at partitions must have wood, rubber vinyl, or carpet base. Any exceptions must be approved by the contracting officer.
- An additional 10 percent of the selected carpet tiles shall be provided by the contractor for the owner's own stock and replacement. These carpet tiles are not to be used during the warranty period.
- The off-gassing requirements in Chapter 4, paragraph 3.b, of the *Safety Manual* shall be followed.

9.4.3 VINYL TILE

Unless otherwise indicated elsewhere in this document, all new vinyl tile shall be 12 inch × 12 inch × 1/8-inch thick, shall have 35 percent to 40 percent reflectance, and shall be high density, meeting the requirements of Federal Specification SS-T-312, Type IV. Adhesives used to set tiles shall be environmentally acceptable. Colors and patterns will be selected from three or more samples by the contracting officer or his or her duly appointed representative.

9.4.4 SEAMLESS VINYL FLOORING

Seamless flooring shall be vinyl seamless flooring, shall be chemical-resistant as manufactured by Tarket or Mipolan or an approved equal, and shall be coved 4 inches up the wall using the same material. Joints shall be chemically welded smooth without any grooves. Adhesive used to set the flooring shall be environmentally acceptable.

9.4.5 CERAMIC TILE FLOORING

Ceramic tile flooring shall be sealed in all grout areas. At least five color samples shall be incorporated into the color boards for selection and approval by the contracting officer (or his or her duly appointed representative).

9.4.6 SPECIAL FLOORING

Special floor-coating systems shall be troweled, jointless floor systems with slip-resistant top coatings which shall be waterproof and resistant to alkalis and acids. The special flooring system selected should be compatible with its intended use.

9.4.7 EXPOSED CONCRETE FLOORING

Steel trowel finish shall be used on exposed concrete floors that will not receive other finish. Exposed interior concrete floors shall be sealed with a penetrating-type solvent base or water-emulsion base unpigmented sealer containing a suitable type resin and no wax.

9.5 Painting

9.5.1 GENERAL

Before occupancy, all surfaces designated for painting must be newly painted with paint finish and colors acceptable to, and approved by, the contracting officer or that officer's duly appointed representative. The contracting officer or duly appointed representative shall be provided with color samples and color schemes, with their average surface reflectance value clearly identified, for selection.

9.5.2 REFLECTANCE VALUES

Minimum average surface reflectance values that will be used as a base for the selection of interior colors are as follows:

- Ceiling: 80 percent.
- Walls: 50 percent.
- Floors: 30 percent.
- Furniture and equipment: 35 percent.
- Chalkboards: Not less than 15 percent nor more than 20 percent, as recommended by the American Illuminating Engineering Society and the American Institute of Architects in their report, *American Standard Practice for School Lighting*, AIA No. 32F28.

9.5.2.1 ADDITIONAL SPECIFICATIONS

Deviations from the above reflectance requirements are allowed for aesthetic treatment of such areas as conference rooms, lobbies, corridors, and executive offices. Surfaces shall also have a matte finish to prevent excessive brightness ratios and to minimize specular reflections.

9.5.3 WALL AND CEILING COLORS

Ceiling color can be extended from 1 to 3 feet down the walls, or to the level of the fixtures, to obtain up to 20 percent increase in illumination.

9.5.4 ACCENT AREAS

Up to 20 percent of wall surfaces may have reflectance values lower than those listed, for accent purposes, without being considered part of the average.

9.6 Window Covering

Permanent devices installed on the outside of buildings to control sunlight are considered sun shades and are discussed in subsection 8.3 of this Manual.

9.6.1 BLINDS

Window blinds in laboratory spaces may be either vertical or horizontal with nonmetallic slats. Color selection will be made by the EPA representative. The hardware and blind mechanisms shall be made of acid-resistant materials.

9.6.2 BLACKOUT SHADES

Rooms requiring blackout capability shall be equipped with blackout shades. Shades should be a preengineered unit with a fiberglass-coated fabric shadecloth. They must have a noncorroding, concealed-variable adjustment mechanism, adjustable from 100 percent friction (static mode) with finite positions to 15 percent friction (dynamic mode) with only preselected positions.

9.6.3 DRAPERIES AND CURTAINS

All draperies, curtains, and similar hanging materials shall be of a noncombustible or flame-resistant fabric (chemically treated). Flame-resistant means that the fabric or films (e.g., thin plastic sheets or cellophane) must meet the performance criteria described in NFPA 701. In addition, draperies, curtains, and other window finishes shall be formaldehyde free and shall meet the off-gassing criteria set forth in Chapter 4, paragraph 3.b, of the *Safety Manual*.

END OF SECTION 9

Section 10 - Specialties

10.1 Magnetic, Liquid Chalk, Dry-Marker Boards and Tack Boards

Magnetic dry-marker boards (liquid chalk) shall be used except when the solvent markers used on these boards would affect operations undertaken in laboratories; chalk-type chalkboards shall not be used. Locations of magnetic dry-marker boards and tack boards shall be determined by the design professional in close coordination with the contracting officer's representative (COR).

10.2 Interior Signage Systems and Building Directory

10.2.1 GENERAL

All signage, identification, room numbering, and building directories shall comply with the requirements of the Americans with Disabilities Act (ADA).

10.2.2 DOOR IDENTIFICATION

Door identification shall be installed in approved locations adjacent to office entrances. The form of door identification must be approved by the COR. Toilet, stairway, and corridor doors must be identified by the international symbol of accessibility at a height of 54 to 66 inches above the floor; wherever possible, such identification should be mounted on the wall at the latch side of the door. Seldom-used doors to areas posing danger to the blind must have knurled or acceptable plastic-abrasive-coated handles. Tactile warning indicators shall not be used to identify exit stairs.

10.2.3 ROOM NUMBERING

A room-numbering and room-naming system is required for the identification of all spaces in the facility. Plans shall be submitted to the COR for review and approval before construction documentation begins.

10.2.4 BUILDING DIRECTORY

A wall-mounted, glass-enclosed directory with lock shall be provided at a conspicuous location in the lobby or entrance of the building. The directory shall be approximately 2 feet by 3 feet in size. The building directory shall be approved by the COR.

10.3 Portable Fire Extinguishers

Portable fire extinguishers shall be provided and located within recessed cabinets, in accordance with National Fire Protection Association (NFPA) 10, Standard for Portable Fire Extinguishers. Portable fire extinguishers shall be provided on the basis of the classes of anticipated fires and the size and degree of hazard affecting the extinguishers' use. Portable fire extinguishers containing halon shall not be used.

10.3.1 FIRE EXTINGUISHER LOCATIONS

Portable fire extinguishers shall be provided in every laboratory room. In the other areas of the building, the minimum number of fire extinguishers needed for protection shall be determined in accordance with NFPA 10, Chapter 3, Distribution of Extinguishers.

- Class A and D extinguishers shall be located so that the travel distance to the respective Class A and D hazard areas does not exceed 75 feet.
- Class B extinguishers shall be located so that the travel distance to the Class B hazard areas does not exceed 50 feet.

- Extinguishers with Class C ratings shall be located on the basis of the anticipated Class A or B hazard.
- One extinguisher may be installed to provide protection for several hazard areas provided that travel distances are not exceeded.

10.4 Safety Devices

Eye and face washing equipment and safety showers must be provided for every laboratory and laboratory support room where chemicals are being utilized, in accordance with the American National Standards Institute (ANSI) Standard Z358.1. At least one double-spray-head, hands-free-operating eyewash shall be provided within every laboratory, or for every two laboratory modules, next to or as close as possible to the source of hazard (e.g., fume hood or other hazard). Safety showers shall be provided in accessible locations that require no more than 10 seconds to reach from hazard locations; safety showers should be no more than 50 feet travel distance from the hazard source. The location and installation of emergency showers and eyewash equipment shall be in accordance with the *Safety Manual*.

10.5 Laboratory Casework

10.5.1 GENERAL

Preferably, all laboratory casework and associated fume hoods required in the facility shall be the product of one manufacturer and shall be installed under the recommendations of that manufacturer. The laboratory casework shall meet the functional, aesthetic, flexibility, and maintenance needs of each user. Unless noted otherwise, all surfaces shall be of stainless steel or another nonporous, durable, corrosion-resistant material. Plastic laminate or other similar facing materials, over wood or composite material, are permitted only when the laminate or surfacing material is certified by the manufacturer to be impervious to acids and other common laboratory solvents.

10.5.2 MODULAR DESIGN

Design of laboratory casework (cabinets, counters, fume hoods, etc.) should be coordinated and compatible. Basic laboratory casework systems shall be composed of modular dimensioned units of modern design consisting of a self-supporting steel frame capable of containing service piping and drain lines and permitting the attachment and/or support of various styles of countertops, sinks, cupsinks, and utility hoses and connections, independently from base cabinet assemblies. Support systems shall provide the flexibility and unlimited horizontal interchangeability of any or all cabinet sizes without removal of the working top or interference of immediate vertical legs, supports, brackets, or framing between cabinets. Fixed laboratory casework shall be similarly flexible. The design of fixed casework shall be approved by the COR.

10.5.3 SUPPORT CAPABILITY

The system shall support work surfaces and steel undercounter cabinets independent of one another. All components shall be self-supporting and essentially independent of the building structure. The system shall support sinks, service fittings, plumbing fixtures, and service and waste lines by utilizing pipe clamps. The assembly shall be designed and manufactured in such a manner that each linear foot of span between supporting elements, is capable of supporting a live load of 200 pounds per linear foot plus a dead load of 50 pounds per linear foot. In addition, it should be possible to place a concentrated load of 250 pounds on the front edge of the assembly at any point (assuming legs spaced at 6 feet on center) without causing the system to fail in its suspension or tip or deflect more than $\frac{3}{16}$ of an inch.

10.5.4 CABINET ASSEMBLIES

Cabinet assemblies shall be suspended from the support system with fastener devices mounted in front of the unit for attachment to the front rail and shall be designed so that removal of units can be easily accomplished by use of common hand tools. Such fastener devices shall be of forged or cast steel and shall be commercially cadmium plated. Filler panels shall be provided at exposed-to-view areas, between backs of cabinets and

walls, between backs of cabinets at the end of the peninsula or island benches, and at knee openings, to allow for the maintenance of mechanical services.

10.5.5 BASE CABINETS

Casework shall be of a metal construction of slimline design and shall be built in accordance with the highest standards and practices of the metal casework industry. Superior quality casework shall be established by use of proper machinery, tools, dies, fixtures, and skilled workmanship so that the fit of doors and drawers allows vertical and horizontal openings of minimum tolerance. All units shall be of flush-front construction so that drawer and door faces are in the same plane as exterior case members. Each unit shall be a completely welded structure and should not require additional parts such as applied panels at ends, backs, or bottom.

10.5.6 WALL CABINETS

Upper wall cabinets shall be designed so that cabinets hang rigidly vertical without sag or tilt. The design professional shall be responsible for ensuring that proper reinforcement is installed at the walls to support the load of the cabinets and contents. Construction of wall cabinets shall be of similar to that of base cabinets; wall cabinets shall be modular in design and installation to permit immediate interchangeability of all wall cabinets and/or shelf units.

10.5.7 SHELVING

The following subsections provide information on reagent and adjustable shelving.

10.5.7.1 REAGENT SHELVES

Reagent shelves shall be 1-inch-thick plywood, faced on both sides with acid-resistant plastic laminate, with all exposed edges edge-banded in 3-millimeter ($1/8$ -inch) thick polyvinyl chloride (PVC).

10.5.7.2 ADJUSTABLE SHELVING

Adjustable shelving shall be 16-gauge steel shelving with hat-section reinforcing and shall be interchangeable with wall-hung cabinets. Shelving standards shall be double-slotted, 30 inches in length, mounted at a height of 54 inches above finished floor (measured to the bottom of the standard). Brackets shall be 16-gauge metal with three blade hooks and shall be screwed to each shelf.

10.5.8 COUNTERTOPS

Countertop materials will vary depending on the intended use. The design professional shall be responsible for evaluating the requirements of the laboratories to determine what countertop material is most suitable for each specific application. The material used for the countertop shall also be used for back-splashes, side-splashes, and services ledge covers.

10.5.8.1 PLASTIC LAMINATE

Chemically resistant plastic laminate countertops may be used in many applications where the use of extremely corrosive chemicals or large amounts of water is not expected.

10.5.8.2 EPOXY RESIN

Epoxy resin countertops shall be utilized in laboratories or in areas where large quantities of water or extremely corrosive chemicals are being utilized on a routine basis. All joints shall be bonded with a highly chemical-resistant and corrosion-resistant cement having properties similar to those of the base material.

10.5.8.3 STAINLESS STEEL

Stainless steel countertops shall be used in special applications where sterile conditions are required (e.g., glassware washing areas, autoclave rooms), where there are controlled environmental temperatures (e.g., cold rooms, growth chambers), and where radioisotopes are being used.

10.5.9 MATERIALS

Standard laboratory casework shall be of metal construction unless otherwise indicated. For rooms that do not require casework of metal construction, the casework materials shall be wood or approved plastic. Hardware used for wood or plastic casework shall be epoxy coated.

10.5.10 QUALITY

The laboratory casework that is subject to the above requirements shall have components, configuration, materials, finish, and performance (including performance on chemical and physical performance tests) comparable to cantilevered frame (C-frame) casework systems manufactured by Hamilton Industries and Kewaunee Scientific Equipment Corporation. Equipment manufactured by others is acceptable if the products are of equal performance and have similar appearance and construction, but only after approval by the contracting officer.

10.5.11 MINIMUM STANDARDS

Performance set forth herein shall establish minimum standards for design, performance, and function. Products that fail to meet these standards will not be considered.

10.5.12 LABORATORY FUME HOODS

Fume hoods shall be provided in all laboratories and laboratory support spaces where hazardous chemicals or other toxic materials are being utilized. The purpose of the laboratory fume hood is to prevent or minimize the escape of contaminants from the hood into the laboratory. The fume hood work surface shall be of recessed design so that spills can be effectively contained. The design professional shall be responsible for determining, with the users of the facility, types and sizes of fume hoods appropriate to their intended use. See Section 15, Mechanical Requirements, of this Manual for more specific requirements.

10.5.12.1 FUME HOOD LOCATION

Fume hoods must be located away from doors and pedestrian traffic. The location of the hood shall be at the end of a room or bay, but not less than 1 foot from the corner, where the operator is essentially the only one who enters the zone of influence. Further, hoods shall be placed in such a way that one hood cannot draw air from another hood.

10.5.13 ENVIRONMENTAL ROOMS

Environmental rooms shall be of modular, insulated panel construction, providing temperature and humidity control with specified setpoint control. Temperature requirements for individual rooms shall be appropriate to the rooms' intended use. Rooms shall be provided with emergency auxiliary power backup to allow 24-hour operation. All rooms involving laboratory procedures shall be ventilated. Fume hoods shall not be allowed in environmental rooms. The following should also be provided: remote air- or water-cooled dual-sequencing compressor, temperature and humidity recorders, high/low alarm, adjustable epoxy-coated wire shelving on wall supports or movable racks, and personnel emergency alarm.

END OF SECTION 10

Section 11 - Equipment

11.1 Design

Planning for equipment shall be integrated with the planning of architectural, structural, mechanical, and electrical systems. Equipment shall be arranged and organized to provide circulation, workflow, and maintenance clearances.

11.2 Catalog Cut Sheets

Appropriate catalog cut sheets shall be provided for all items of equipment. Each cut sheet shall have a logistical category and code. Each item shall be clearly identified if it has unique utility requirements, structural support needs, or space requirements.

11.3 Layout and Clearances

Equipment should be arranged to provide service clearances and maintenance access so that service and maintenance can be executed with minimum disruption to workspaces. When expansion is anticipated in a project, the design professional should ensure that some additional equipment can be added without disruption or reconfiguration of workflow.

11.4 Floor Preparation

Floor depressions shall be provided to accommodate items and design requirements, such as cart washers, environmentally controlled room equipment, walk-in refrigerators, computer rooms, and any other appropriate spaces or items, except in laboratory spaces where future flexibility is a requirement.

11.5 Structural Support

Wall-partitioning systems for wall-hung equipment and toilet accessories shall be adequately reinforced. Ceiling support systems for service columns, hoist equipment, and other ceiling-mounted items shall be structurally braced. All fixed equipment shall be mounted to resist seismic forces in accordance with seismic levels defined for each applicable project.

11.6 Special Ventilation Requirements for Equipment

Control of ventilation for the employee working environment must be provided by the equipment supplier. All requirements of Appendix B, Indoor Air Quality, shall be addressed.

11.7 Equipment Specifications

Equipment specifications shall be developed for all equipment that does not have current guide specifications. All equipment specifications should permit procurement of the most current model of equipment through General Services Administration (GSA) services where possible. All equipment specifications should be developed to accommodate reputable vendors. Equipment specifications should discuss the scope of services to be provided by mechanical and electrical contractors installing Government-furnished equipment.

11.8 High-Technology Equipment

Project-specific guidance should be obtained on high-technology equipment. Design shall be in accordance with selection and guidance of the respective manufacturers.

11.9 Mechanical and Electrical Equipment

Refer to Sections 15 (Mechanical Requirements) and 16 (Electrical Requirements) of this Manual for information on mechanical and electrical equipment, respectively.

11.10 Equipment Consultants

Use of an equipment consultant is recommended for defining and specifying what research equipment must be procured. Such consultants shall also provide information on equipment during the design and construction document phases to assist in planning and documentation.

END OF SECTION 11

Section 12 - Furnishings

12.1 Furnishings

No material specific to furnishings is included in this Manual.

Information on “Green” specifications can be obtained from the Architecture, Engineering and Real Estate Branch (AEREB). Sample copies of Green Rider provisions are available to assist in determining Green furnishings. Additional information may be obtained from the Green Buildings Council.

END OF SECTION 12

Section 13 - Special Construction

13.1 Noise Control

Noise levels in the different rooms of the facility should be in accordance with the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) handbook, *HVAC Systems and Applications*, Chapter 52 (Sound and Vibration Control). Proper schematic planning should isolate noise-sensitive areas from noise sources by separation with a nonsensitive buffer area. In addition, dedicated laboratory support spaces should be provided to isolate noise-producing equipment, such as centrifuges and vacuum pumps, from laboratories. In any instrument or laboratory space in which one or more fume hoods are used, the noise level should be 55 or less decibels of sound measured on an A-scale (dBA) but shall not exceed 70 dBA at the working position in front of the hood.

The combined noise resulting from several pieces of equipment shall not exceed 65 dBA when measured 3 feet from any piece of equipment. Noise generated from vibration by heating, ventilation, and air-conditioning (HVAC) systems may be minimized by several means: judicious equipment selection; limitation of fluid flow velocities; isolation of key mechanical, piping, and ducting systems; and other prudent engineering and architectural means.

13.1.1 VIBRATION ISOLATION

Vibration isolation systems should be provided on rotating mechanical equipment of greater than ½ horsepower (hp) (for equipment located within a critical area), greater than 5 hp (for other areas in the building), and greater than 10 hp (outside and within 200 feet of the building). Reciprocating equipment (other than emergency equipment) shall not be used. Vibrating equipment shall not be placed on top of buildings, unless no other locations are feasible. Vibrating equipment that must be mounted on the roof shall be placed directly over columns and on pads and springs to totally isolate the vibration from the building structure.

- Concrete inertia bases will be used with rotating mechanical equipment handling liquids (e.g., pumps) and with compressors. Steel frames will be used for air-handling equipment.
- Flexible pipe connectors (e.g., twin-sphere connectors) will be used on piping connecting to isolated equipment and where piping and ducting exit the mechanical room(s).
- Flexible duct connectors will be used in a manner similar to flexible piping connectors.

13.1.2 PIPING AND DUCTING SYSTEMS

Passive piping and ducting systems are defined as those that are at a great distance from their energy source and have low flow rates and/or infrequent use (examples of such systems are city water, gases, and waste water). Conversely, active piping systems are defined as those that are close to energy sources and can constitute a major vibration problem requiring isolation.

- Active piping and ducting shall be sized for economical flow velocities.
- Ducts that are less than 24 inches in diameter do not require isolation, provided that the flow velocities do not exceed 1,200 feet per minute. Ducting that does not meet this requirement shall be isolated.
- Active piping associated with HVAC (chilled water, condenser water, hot water, steam, and refrigerant piping) within mechanical rooms, or at least 50 feet (whichever distance is greater) from connected vibration-isolated equipment (e.g., chillers, pumps, air handlers) or from the ground, shall be isolated from the building structure; resilient penetration sleeves shall be used where this piping penetrates walls.

Flexible piping connectors shall be used where the piping leaves the mechanical room. All active piping in the critical area having a diameter of 4 inches or less shall be isolated.

13.1.3 SOUND DAMPENING

Sound dampening features (acoustical treatment), preferably of rigid materials, shall be provided in instrument rooms so that the noise level does not exceed 55 decibels (dBa). If a hood is required in these rooms, the noise level shall not exceed 70 dBa at the face of the hood.

13.2 Fire Walls and Fire Barrier Walls

Fire walls must be structurally independent and have sufficient structural stability under fire conditions to allow collapse of construction on either side of the firewall without collapse of the fire wall itself. The wall is also required to allow collapse of the structure on one side without compromising the integrity of the structure on the opposite side of the fire wall. Fire walls differ from fire barrier walls, which do not require structural stability. Fire barrier walls may rely on the building structure for support. Refer to National Fire Protection Association (NFPA) 221 for specific criteria related to fire walls and fire barrier walls.

13.2.1 FIRE WALLS

Every fire wall shall be made of noncombustible material with the fire-resistance rating required by local codes for segregating the building into separate buildings or fire areas. Openings in fire walls shall be protected as noted in subsection 13.2.3 below. Unprotected windows are not allowed in fire walls.

13.2.2 FIRE BARRIER WALLS

Unless other fire-resistive construction is provided to create a complete enclosure on all sides, all fire barrier walls must extend from floor slab to floor slab or to roof deck. Openings in fire barrier walls shall be protected as noted in subsection 13.2.3 below.

13.2.3 OPENINGS

Openings in fire walls and fire barrier walls shall be protected with fire-rated components capable of maintaining the fire-resistive integrity of the wall. The minimum fire-resistance requirement for protection of openings in fire walls and fire barrier walls shall be the more restrictive of Chapter 6 of NFPA 101 and the local building code. Greater fire resistance may be required by code requirements for specialized occupancies such as computer rooms and laboratories. Fire window assemblies are allowed in fire barrier walls with a 1-hour or lower fire-resistance rating. The maximum allowed glazing area in windows shall be the maximum area tested and shall be in accordance with NFPA 80. Refer to Chapter 2 of the *Safety Manual* for restrictions on utilities penetrating required fireproofing.

13.3 Vertical Openings and Shafts

Fire-resistance ratings for enclosures of vertical openings and shafts shall conform to the requirements in NFPA 101, Chapter 6. Openings into vertical openings and shafts shall be protected by fire doors or fire dampers as outlined in subsection 13.3.2 and in Chapter 2, Basic Fire Safety Standards, of the *Safety Manual*.

13.3.1 ATRIUMS

Atriums and other openings, where permitted by NFPA 101 and the local building code, shall be protected in accordance with Chapter 6 of NFPA 101. In addition, exits shall be separately enclosed from the atrium. Access to exits is permitted to be within the atrium space.

13.3.2 SHAFTS

When telephone rooms, electrical closets, and similar spaces are located one above the other, the enclosure walls are considered to form a shaft, and protection shall be provided in accordance with the requirements of NFPA 101 and the local building code. Shafts shall not be installed between a structural member and the fireproofing for that member. If allowed by the local building code, all floor penetrations within telephone

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and electric closets can be sealed or otherwise grouted, in lieu of creating a shaft, to maintain the fire resistance of the floor assembly.

Structural members passing through a shaft shall be fireproofed separately from the shaft enclosure so that the entire structural member is protected as required by the model building codes. The fireproofing shall be of concrete, plaster, or other hard material that is resistant to mechanical damage and not subject to rusting or corrosion.

13.3.3 MONUMENTAL STAIRS

Large, open stairs shall be protected by one of three methods. If the stairs are not involved in the building exit requirements, they may extend one floor above and one floor below the main entrance lobby, provided that fire partitions and self-closing fire doors are installed at the upper and lower levels. Alternatively, they may be protected as a vertical opening in accordance with the requirements of Chapter 6 of NFPA 101. If the stairs are part of the exit system, they must be protected as outlined in Chapter 5 of NFPA 101.

13.3.4 ESCALATORS

Escalators shall be treated in the same manner as monumental stairs with the additional option of using curtain boards and sprinkler protection as detailed in NFPA 13.

13.3.5 PENETRATIONS

Openings around penetrations in vertical openings and shafts shall be fire-stopped as described in subsection 13.3.2 above.

END OF SECTION 13

Section 14 - Conveying Systems

14.1 General

Elevators, dumbwaiters, escalators, and moving walks shall be in accordance with American National Standards Institute (ANSI) Standard A17.1. Other requirements are described below.

14.2 Elevators

14.2.1 ELEVATOR RECALL

All automatic elevators having a travel distance of 25 feet or more shall be recalled when any fire alarm-initiating device, such as elevator lobby smoke detectors, manual fire alarm stations, or sprinkler system waterflow switches, is activated. All elevators must be recalled when the recall system is activated. Smoke detectors other than those required by ANSI A17.1 shall not initiate automatic elevator recall.

14.2.2 SMOKE DETECTORS

Smoke detectors shall be provided for every elevator lobby, including the main lobby. Smoke detectors that activate the automatic elevator recall are also required in the elevator machine rooms. Elevator lobby smoke detectors should not initiate the building fire alarm system but shall send an alarm to the fire department or central station service and shall activate the elevator recall system.

14.2.3 CAPTURE FLOOR

An alternate capture floor shall be provided in accordance with Rule 211.3b(2) of ANSI A17.1. Activation of an alarm-initiating device on the main capture floor shall return the elevators to the alternate capture floor.

14.2.4 SIGNAGE

Signs must be placed in the elevator lobbies next to all elevators to inform occupants not to use the elevators if there is a fire.

14.2.5 CHEMICAL TRANSPORT USE

If elevators are used to transport chemicals, provisions shall be made to ensure that nonlaboratory personnel and space (administrative or business occupancies) are not exposed to or contaminated by chemical substances. For example, chemicals must be packaged in accordance with U.S. Department of Transportation (DOT) specifications, or an alternative route of transport must be provided. This alternative route may include an elevator opening into a vestibule separate from administrative or business occupancies, a multiple-door elevator entering into a laboratory, separate dumbwaiters, or alternate corridors or routes. A combination of these options can be used to achieve this goal.

14.3 Escalators

Escalators shall be treated in the same manner as monumental stairs with an additional option of providing curtain boards and sprinkler protection as detailed in National Fire Protection Association (NFPA) 13.

END OF SECTION 14

Section 15 - Mechanical Requirements

15.1 General

The design professional shall be responsible for ensuring that all mechanical systems conform to the requirements of this section and that all systems are installed and operating in accordance with all governing codes, ordinances, and regulations; the most current edition of applicable publications; and as set forth below. The design professional is responsible for the design of all mains, lines, meters, and other mechanical components required for utility services. The building air-conditioning, heating, and ventilation systems shall provide a safe and suitable environment both for occupants and for functional operation of the facility.

15.2 References

All work discussed in this section shall comply with all applicable federal, state, city, and local codes, regulations, ordinances, publications, and manuals. When codes or publications conflict, the most stringent standard shall govern. Unless otherwise specified in this Manual or approved by the Architecture, Engineering and Real Estate Branch (AEREB) and the Safety, Health and Environmental Management Division (SHEMD), all mechanical system installations shall conform to the applicable requirements of the following National Fire Protection Association (NFPA) and American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) standards, American National Standards Institute (ANSI) safety codes, and other sources in the following list:

- Carbon Dioxide Extinguishing Systems (NFPA 12)
- Installation of Sprinkler Systems (NFPA 13)
- Installation of Standpipe and Hose Systems (NFPA 14)
- Water Spray Fixed Systems (NFPA 15)
- Dry Chemical Extinguishing Systems (NFPA 17)
- Wet Chemical Extinguishing Systems (NFPA 17A)
- Installation of Private Fire Service Mains and Their Appurtenances (NFPA 24)
- Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems (NFPA 25)
- Automotive and Marine Service Station Code (NFPA 30A)
- Installation of Oil Burning Equipment (NFPA 31)
- Spray Application Using Flammable and Combustible Materials (NFPA 33)
- Stationary Combustion Engines and Gas Turbines (NFPA 37)
- Fire Protection for Laboratories Using Chemicals (NFPA 45)
- National Fuel Gas Code (NFPA 54)
- Storage and Handling of Liquefied Petroleum Gases (NFPA 58)
- Storage and Handling of Liquefied Natural Gas (NFPA 59A)
- Protection of Electronic Computer/Data Processing Equipment (NFPA 75)
- Installation of Air-Conditioning and Ventilating Systems (NFPA 90A)
- Installation of Exhaust Systems for Air Conveying of Materials (NFPA 91)
- Smoke Control Systems (NFPA 92A)
- Ventilation Control and Fire Protection of Commercial Cooking Operations (NFPA 96)
- Water Cooling Towers (NFPA 214)
- Water Supplies for Suburban and Rural Firefighting (NFPA 1231)
- Clean Agent Fire Extinguishing Systems (NFPA 2001)
- Elevators, Dumbwaiters, Escalators, and Moving Walks (ANSI A17.1)
- Ventilation for Acceptable Indoor Air Quality (ANSI/ASHRAE 62)
- Emergency Eyewash and Shower Equipment (ANSI Z358.1)
- Laboratory Ventilation (ANSI/American Industrial Hygiene Association [AIHA] Z9.5)

- Quantitative Performance Test for Laboratory Fume Hoods (ASHRAE 110-1985)
- Method of Testing Performance of Laboratory Fume Hoods (ANSI/ASHRAE 110, as modified per EPA requirements)
- *Procedures Manual for Certifying Laboratory Fume Hoods To Meet EPA Standard*
- Safety Code for Mechanical Refrigeration (ANSI/ASHRAE 15)
- Fire Suppression Rating Schedule (Insurance Services Office)
- *Building Air Quality: EPA Guide for Building Owners and Facility Managers*, EPA/400/1-91/033 or December 1991
- *Industrial Ventilation: A Manual of Recommended Practice*, American Conference of Government Industrial Hygienists (ACGIH)
- *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, National Research Council, 1995
- Scientific Equipment and Furniture Association (SEFA) 1/1994
- National Sanitation Foundation (NSF) standard 49 for Biohazard Safety Cabinets.

15.3 Heating, Ventilation, and Air-Conditioning Requirements

A heating, ventilation, and air-conditioning (HVAC) system that will satisfy the requirements indicated in this document shall be provided. The air-conditioning and refrigeration equipment for the mechanical systems shall not use chlorofluorocarbon (CFC) refrigerants. The use of hydrochlorofluorocarbon (HCFC) will be permitted only if the equipment required cannot be replaced with equipment that uses a non-ozone-depleting refrigerant.

15.3.1 GENERAL

Building HVAC systems and subsystems shall be evaluated, and major HVAC equipment components shall be selected on the basis of a consideration of health and safety requirements, initial costs, operating costs, and maintenance costs. A life cycle cost analysis (LCCA) done with a nationally recognized computer program shall be performed to select the most cost-effective HVAC system.

15.3.2 HVAC SYSTEM PERFORMANCE

HVAC system performance shall meet the following requirements.

- 15.3.2.1 Indoor space shall meet the EPA National Ambient Air Quality Standards. As established in ASHRAE 62-1989, HVAC systems will be designed and operated to provide:
- 20 cubic feet per minute (cfm) of outdoor air per person in offices and 20 cfm of outdoor air per person in laboratories.
 - 60 cfm of outdoor air per person in smoking lounges, which also must have local mechanical exhaust with no air recirculation.
 - A local mechanical exhaust with no air recirculation for copy rooms and rooms with similar stationary sources of contaminants.
- 15.3.2.2 Installation of new furniture, rugs, or drapery that may off-gas chemical contaminants (particularly in a facility that minimally meets the HVAC performance criteria listed above) should, ideally, be done with at least 48 hours of off-gassing time before occupancy. Providing a high rate of fresh air ventilation during this time will increase the effectiveness of the off-gassing process. This procedure should be used to speed dispersion of gases, vapors, and other potentially harmful building products resulting from activities such as painting and application of pesticides.

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15.3.2.3 HVAC intakes should be located as far as possible from cooling towers, vehicle exhaust sources, and laboratory hood exhaust systems. The position and design of the HVAC intakes should minimize potential contamination from such sources, both on-site and off-site.

15.3.2.4 For maintenance program requirements, see the *Safety Manual*.

15.3.3 SELECTION PROCEDURE

HVAC equipment shall be sized to satisfy the building and cooling load requirements and to meet all equipment design and selection criteria contained in the ASHRAE *Fundamentals*, *HVAC Systems and Equipment*, *HVAC Applications*, and *Refrigeration* handbooks.

15.3.3.1 INSIDE DESIGN TEMPERATURES

Environmental design temperatures and relative humidities for special space uses other than those listed here shall be designated in the project criteria. The design temperatures shall be 5 degrees Fahrenheit (°F) lower for cooling, and 5°F higher for heating, than the required operating temperature.

- When space cooling is required, the inside design temperature (design values are not necessarily the same as operational values) for maintaining personnel comfort shall be 70°F, dry bulb (db), unless otherwise indicated in project criteria. The relative humidity shall be 50 percent. Summer humidification shall not be provided for personnel comfort. Cooling systems shall be designed to maintain the relative humidity conditions of space through the normal cooling process and should not have controls that limit the maximum relative humidity unless system type or project-specific criteria dictate.
- The inside design wintertime temperature (design values are not necessarily the same as operational values) for personnel comfort shall be 77°F db unless otherwise indicated here or directed by other project-specific criteria. Table 15.3.3.1, Inside Design Temperatures (Heating), shows the design temperatures for a number of space uses.
- Except where it can be substantiated from records or engineering computations that the inside relative humidity will be less than 30 percent, winter humidification for personnel comfort and health shall not be provided. Where such a condition has been substantiated, a design relative humidity of 30 percent shall be used in establishing minimum requirements for humidification equipment.

TABLE 15.3.3.1 Inside Design Temperatures (Heating)

Temperature (°F db)	Space
As indicated by project criteria	Storage (unoccupied)
55	Storage (occupied)
50	Warehouses
60	Kitchens
65	Laundries
65	Shops (high work activity)
70	Toilets
75	Change rooms (heating only when occupied)
As indicated by project criteria	Specialty rooms (e.g., laboratories, clean rooms)

15.3.3.2 OUTSIDE DESIGN TEMPERATURES

The HVAC system equipment shall be designed by using the outside design temperatures shown in Table 15.3.3.2, Outside Design Conditions, for the particular application. The percentages of dry bulb and wet bulb (wb) temperatures are derived from the sources of tabulated weather data described below. When data for a particular location are not listed, design conditions shall be estimated from data available at nearby weather stations or by interpolation between values from stations, taking into account elevation and other local conditions affecting design data. Weather data for use in sizing HVAC equipment shall be obtained from one or more of the following:

- Local weather station
- ASHRAE *Handbook of Fundamentals*.

Table 15.3.3.2 Outside Design Conditions

Winter	Summer	Application
99% db	1% db and mean coincident wb	Process, laboratory, and other uses where close temperature and humidity control is required by project criteria
97.5% db	2.5% db and mean coincident wb	Personnel comfort systems
—	1% wb	Cooling towers* and research, technical-type systems
—	1% db plus 5°F	Air-cooled condensers*

*Temperature should be verified by reviewing actual site conditions.

15.3.3.3 EQUIPMENT SIZING

The capacity of central heating, refrigeration, and ventilation equipment shall be set for the peak block building or the maximum simultaneous zone heating and cooling design loads and in accordance with the *ASHRAE Handbook of Fundamentals*. The equipment shall not be sized for future additional capacity or to provide redundancy unless indicated in project-specific criteria. Individual zone equipment shall be sized according to the peak zone load.

15.3.3.4 EVAPORATIVE/ADIABATIC COOLING

In locations where a wide variation exists between the dry bulb and wet bulb temperatures for extended periods of time, evaporative/adiabatic cooling shall be considered for the applications listed below. Selection of cooler types shall depend on system configuration, user experience, and LCCA. All evaporative coolers shall maintain a positive water-bleed and water-makeup system for control of mineral buildup.

- Applications for which evaporating adiabatic cooling are considered include warehouses, shops that do not require close (within 5°F plus or minus) temperature control, nonresidential-size kitchens, makeup air ventilation units, and mechanical equipment spaces.
- Air duct design, number and location of coolers, and relief of the higher rate of air supply to the atmosphere shall be considered as means of ensuring a satisfactory operating system. Multistage evaporative cooling systems shall also be considered.
- Indoor design dry bulb temperatures for spaces that are air-conditioned by adiabatic cooling systems shall be as specified in project-specific criteria. Design operating efficiency of adiabatic cooling equipment shall be at least 70 percent. System-installed capacity shall be based on the peak design cooling load for the air-conditioned space. An arbitrary air-change rate shall not be used for design airflow. Adiabatic cooler specifications shall be stated in terms of the air capacity, the entering ambient dry and wet bulb temperatures, and the leaving dry bulb temperature.

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15.3.4 VENTILATION-EXHAUST SYSTEMS

All processes, operations, or other situations that present the possibility of hazardous accumulation of combustible or explosive vapors, dust, fumes, or other airborne substances shall be provided with ventilation facilities in accordance with NFPA 91 and NFPA 45. Ventilation-exhaust systems shall be selected for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists, and excessive heat and for the provision of fresh air to occupants. The design criteria contained in this subsection shall be followed in determining the required air quantity and quality for ventilation and exhaust systems.

- 15.3.4.1 Use of exhaust stack(s) to provide exhaust air dispersion and prevent exhaust-to-intake return of air to the facility or to an adjacent facility shall be considered. Local weather and site conditions, along with guidance found in the ASHRAE *Handbook of Fundamentals* shall be used to determine an appropriate solution.
- 15.3.4.2 Areas from which air shall not be recirculated include areas that produce or emit dust particles, heat, odors, fumes, spray, gases, smoke, or other contaminants that cannot be sufficiently treated and could be injurious to health and safety of personnel or damaging to equipment. These areas shall be 100 percent exhausted (e.g., fume hood exhausts). Project criteria shall indicate other areas of nonrecirculation.
- 15.3.4.3 Restrooms, janitor closets, garbage rooms, and other malodorous spaces shall be exhausted at a rate of not less than 50 cfm per toilet or urinal, and as specified in ASHRAE standard 62 or in local building codes, whichever is the more stringent, regardless of any other calculated ventilation requirements.
- 15.3.4.4 Air from adjacent spaces should be used as the ventilation supply air for the 100 percent exhausted spaces, as long as:
- Ventilation by this method does not violate any requirements of NFPA 90A or NFPA 101 or special space pressurization requirements.
 - The air supplied is not potentially more hazardous than the air from the space being exhausted.
 - Adjacent spaces are not laboratory or specialty spaces requiring once-through ventilation.
- 15.3.4.5 Industrial-type facilities and laboratories shall be provided with ventilation (supply and exhaust) systems as required for heat exposure control or dilution ventilation. Ventilation air shall be provided in the quantities required to comply with Occupational Safety and Health Administration (OSHA) air quality requirements. Design air quantities and transport velocities shall be calculated according to the methods prescribed in the ASHRAE *Handbook of HVAC Systems and Equipment*, the ASHRAE *Applications Handbook*, the ACGIH *Industrial Ventilation* manual, and NFPA 45.
- 15.3.4.6 Cooking equipment used in processes that produce smoke or grease shall be designed and protected in accordance with NFPA 96. Any insulation shall be of noncombustible materials. If other utilities are included in a vertical shaft with the grease duct, they shall not be insulated or lined with combustible materials.
- 15.3.4.7 The guidelines in the ASHRAE *HVAC Applications Handbook* (under the topic of Laboratories) shall be followed in designing laboratories and laboratory buildings, except where the standards in this Manual are more stringent. Makeup air shall be provided in the quantities needed to maintain required positive or negative room static pressure and to offset local exhaust air quantities. Makeup air shall be tempered.

15.3.5 EQUIPMENT ROOM VENTILATION

Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed National Electrical Manufacturers Association (NEMA) equipment ratings. The project criteria shall establish the space temperature limits. Where mechanical ventilation cannot maintain a satisfactory environment, evaporative cooling systems (indirect evaporative cooling for electrical rooms) or other mechanical cooling systems shall be provided. Exhaust air openings should be located adjacent to heat-producing equipment to minimize ambient thermal loads.

- Thermostatic controls shall be used to operate the ventilation and exhaust systems.
- Equipment rooms containing refrigeration equipment shall be ventilated in accordance with ASHRAE standard 15.
- For all equipment rooms with fuel-burning appliances or equipment, combustion air for these appliances and this equipment shall be drawn directly from the outside, in accordance with Building Officials and Code Administrators International, Inc. (BOCA) Basic/National Mechanical Code.

15.3.6 WASTE HEAT RECOVERY SYSTEMS

Energy conservation and waste heat recovery systems shall be considered and designed according to the procedures outlined in specific chapters of the *ASHRAE Fundamentals, Systems and Equipment, Applications, and Refrigeration* handbooks, and the Sheet Metal and Air-Conditioning Contractors National Association (SMACNA) *Energy Recovery Equipment and Systems Manual*. The following types of heat-recovery methods and systems shall be considered for incorporation into the building HVAC system design where appropriate.

- Use of rotary heat exchanger, heat pipe, or coil runaround systems for heating and air-conditioning air-handling systems.
- Recovery of rejected heat from the condenser systems of central station cooling equipment for use in heating the remainder of the building (when the central station cooling equipment must operate during the heating season to cool computer rooms or high internal gain areas or to meet process requirements).
- Use of exhaust heat from the condenser systems of continuously operated refrigeration equipment for space heating or domestic hot-water heating.
- Use of a free cooling system that uses cooling tower water (water-side economizer) when air-side economizer systems are not feasible.
- Use of a heat pump runaround loop.

15.3.7 ENERGY EFFICIENCY

After a careful study of the facility's requirements as well as of the day-to-day operation of its various departments has been made, systems shall be designed that meet the operating requirements in an energy-efficient manner. The local utility companies shall be contacted to investigate the system dollar credits for load shifting to off-peak times. The health and safety aspects of the operation must be given first priority, and they cannot be relaxed or traded off for greater efficiency.

15.3.8 LABORATORY

Requirements specific to laboratory spaces are as follows.

15.3.8.1 GENERAL

Laboratory spaces shall be designed with 100 percent outside air (OSA) ventilation systems. In no circumstances will the air supplied to any laboratory space be recirculated to any other space.

15.3.8.2 LABORATORY PRESSURIZATION

Laboratory spaces shall be designed to maintain a pressurization level, relative to other common spaces, that is appropriate for the type of work performed in each laboratory and is negative to the laboratory corridor. In general, biology and chemistry laboratories shall be maintained with a negative pressurization relative to common spaces to ensure containment of odors and contaminants. Levels of pressurization shall be project specific.

15.4 Energy Management Control Systems

15.4.1 GENERAL

This subsection covers safety and operating controls, automatic temperature and humidity controls, energy monitoring and (central supervisory) control systems, energy conservation requirements for controls, and zoning requirements and restrictions.

- Special control requirements shall be indicated in the project-specific criteria. Control systems and associated equipment shall be chosen on the basis of cost and maintainability.
- Control air compressors shall be duplex nonlubricated type with oil-lubricated crankcase and distance piece. Air shall be filtered and dried by refrigerated air dryers for dew point of 15°F and above, and by regenerative silica air dryers for dew point below 15°F.
- Copper piping shall be used for high-pressure air in inaccessible locations (plastic piping may be used if it is installed in conduit). Air leakage shall not exceed 5 percent of pressure in 24 hours. Transmitters shall be capable of being field calibrated, and thermometers or pressure gauge ports shall be provided at transmitters. All controllers and thermostats shall be pilot-bleed type.

15.4.2 ZONING

Zoning for automatic control of space temperature, static pressure, humidity, ventilation, and smoke and fire detection shall satisfy health and safety requirements as indicated in the project criteria. Zoning requirements are as follows:

- Automatic controls shall be provided to shut off heating or cooling to any individual zone or central air-handling unit.
- Interior zones shall not be combined with external zones if this can be avoided.
- Interior space zones shall be placed on separate air-handling systems from external zones, if such placement is cost-effective. External space zones shall be selected for each individual exposure.

15.4.3 CONTROL SETBACK AND SHUTOFF DEVICES

Automatic control setback and shutdown devices with a manual override feature shall be provided for all HVAC systems except those used for spaces for research or process and those used for other environmentally sensitive spaces identified by the project criteria as requiring constant year-round temperature or humidity control. Use of separate, or dual-setting, thermostats, switches, time clocks, or connections for on/off control through the energy management system (EMS) shall be considered for control of air-conditioning to raise the cooling setpoint with humidity override during unoccupied periods in the summer and to control the heating setpoint during unoccupied periods in the winter.

15.4.4 HUMIDITY CONTROL

Summer and winter space or zone humidity control shall be provided only on a space-by-space or zone-by-zone basis and not for the entire central ventilation system unless required for project-specific humidity requirements as stated in the project criteria. No controls shall be provided for dehumidifying spaces to

below 50 percent relative space humidity or for humidifying spaces to greater than 30 percent relative space humidity unless required by project-specific criteria.

15.4.5 SIMULTANEOUS HEATING AND COOLING

Simultaneous heating and cooling, which controls comfort conditions within a space by reheating or recooling supply air or by concurrently operating independent heating and cooling systems to serve a common zone, shall not be used except under the following conditions:

- Renewable energy sources are used to control temperature or humidity.
- Project-specific temperature, humidity, or ventilation conditions require simultaneous heating and cooling to prevent space relative humidity from rising above special-space relative humidity requirements.
- Project-specific building construction constraints, as established in the project criteria, prohibit installation of other types of HVAC systems.

15.4.6 MECHANICAL VENTILATION CONTROL

All supply, return, and exhaust ventilation systems shall be equipped with automatic and manual control of fan operation to shut off the fan when ventilation is not required. To prevent introduction of outside air when ventilation is not required, these systems shall also be provided with manual gravity-operated or automatic control of dampers for outside air intake and exhaust or relief. Systems that circulate air shall be provided with minimum outdoor air damper position control to ensure that the minimum amount of outdoor air is being introduced into the system. Unless otherwise required by life safety or the specific project criteria, automatic dampers should fail open for return air and fail to a minimum setting for outside air.

15.4.7 ECONOMIZER CYCLE

Where feasible, all air-handling systems that recirculate air and are used for space cooling shall be designed to automatically use outside air quantities of up to 100 percent of the fan system capacity for cooling the space. Economizer cycle control shall not be used for air-handling systems in which introduction of the additional outside air would actually increase energy consumption.

- The economizer cycle control system shall have a reset feature.
- The economizer cycle control system shall be designed with a relief air control cycle designed to positively relieve the supply air from the space by sequencing return or relief fans or dampers to maintain a constant room static pressure. Systems that use the economizer cycle should be provided with adequate air filtration to handle the quality of the outside air.

15.4.8 AUTOMATIC CONTROL DAMPERS

Automatic air control dampers must be of the low-leakage type with a maximum leakage of 6 cfm per square foot at a maximum system velocity of 1,500 feet per minute (fpm) and a 1-inch pressure differential, as stipulated in Air Movement and Control Association (AMCA) standard 500. The dampers shall be opposed-blade type for modulating control, but may be parallel-blade type for two-position control. Pilot positioners and operators shall be out of the airstream.

15.4.9 VARIABLE-AIR-VOLUME SYSTEM FAN CONTROL

Variable-air-volume (VAV) systems shall be designed with control devices that sense ductwork static air pressure and velocity air pressure, and control supply-fan airflow and static pressure output through modulation of variable inlet vanes, inlet/discharge dampers, scroll dampers, bypass dampers, variable pitch blades, or variable frequency electric drive controls, as described in ASHRAE *HVAC Applications Handbook*, Chapter 41, and ASHRAE *Handbook of HVAC Systems and Equipment*, Chapter 18. These

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control systems shall have a minimum of one static pressure sensor mounted in ductwork downstream of the fan and one static pressure controller to vary fan output through either the inlet vane, the damper, the belt modulator, or the speed control. Exhaust fans, supply fans, and return or relief fans shall have devices that control the operation of the fans to monitor air volumes and maintain fixed minimum outdoor air ventilation requirements.

15.4.10 FIRE AND SMOKE DETECTION AND PROTECTION CONTROLS

All air-handling systems shall be provided with the smoke and fire protection controls required by NFPA 72.

- All supply, return, relief, and exhaust air ventilation systems shall have interlock controls that interface with the fire and smoke detection system controls. In the event of fire, these interlock controls shall either turn off or selectively operate fans and dampers to prevent the spread of smoke and fire through the building. These controls shall comply with NFPA 90A.
- Special exhaust systems shall be designed to include fire and smoke safety controls as required by NFPA 91. Kitchen exhaust ductwork systems shall be designed to include all fire and smoke safety controls as required by NFPA 96.
- Engineered smoke pressurization and evacuation systems shall comply with the following:
 - NFPA 90A
 - NFPA 72
 - ASHRAE manual, *Design of Smoke Control Systems for Buildings*
 - ASHRAE *Handbook of HVAC Systems and Equipment*.
- Special hazard protection systems that initiate an alarm shall be in accordance with the provisions in Section 16, Electrical Requirements, of this Manual.

15.4.11 GAS-FIRED AIR-HANDLING UNIT CONTROL

Gas-fired air-handling units shall be equipped with operating limit, safety control, and combustion control systems. Gas burner and combustion controls shall comply with Factory Mutual (FM) loss prevention data sheets and be listed in the FM Approval Guide. Gas-fired air-handling units shall have controls that lock out the gas supply in the following conditions:

- Main or pilot flame failure
- Unsafe discharge temperature (high limit)
- High or low gas pressure
- No proof of airflow over heat exchanger
- Combustion air loss
- Loss of control system actuating energy.

15.4.12 ZONE CONTROL/DISTRIBUTION SYSTEM CONTROL

Each zone or air-handling system shall be designed with individual terminal unit-valved control. Use of either two-way or three-way valves shall be considered on the basis of part-load pump performance requirements and potential pump boiler horsepower (bhp) savings.

Water systems that vary the load to the terminal by varying water flow rates with two-way control valves shall be provided with differential pressure controls to reduce system pressure buildup and save energy. These controls shall either signal control valves to route water flow around terminal devices, signal variable-speed pumping controls to reduce pump speed, or turn off one or several pumps working in parallel or series.

15.4.13 CONTROL VALVE SELECTION

Temperature control valves shall be either two-way or three-way proportioning-type valves. Control valves shall be calibrated to allow for a 3-to-5 pound-per-square-inch (psi) pressure differential across the valve or a pressure differential of 50 percent of the combined branch piping and coil pressure drop, whichever is greater. Control valves shall use either pneumatic, electric, electronic, or self-contained controllers. Valves in cooling and heating systems shall be fail-safe. Valve operators shall be selected to close against pump shutoff head for two-way valves.

15.4.14 TWO-PIPE AND THREE-PIPE COMBINATION HEATING AND COOLING SYSTEMS

For fan coil terminal devices with one coil, control valves shall be operated by a room or coil discharge temperature thermostat that can change from summer to winter operation. For air-handling units with heating and cooling coils, control valves shall be controlled by normal sequences of operation but shall be provided with two-position control valves in the piping entering each coil, to prevent hot water from entering the cooling coil and chilled water from entering the heating coil and to sequence on/off and summer and winter operation.

If the two-pipe or three-pipe water distribution system is not provided with heat exchangers to isolate the boilers and chillers from the distribution system, a control system that uses three-way control valves to control and route water around the source devices shall be designed to prevent hot water from entering the chiller and cold water from entering the boiler during the changeover periods from heating to cooling systems.

15.4.15 LOAD CONTROL FOR HOT-WATER SYSTEMS

The temperature of hot water for building heating systems shall be controlled by a supply temperature sensor that modulates the boiler-operating controls. If feasible, the supply delivery temperature shall be reset on the basis of either the temperature outside (lowering the delivery temperature as the outdoor air temperature rises and raising the delivery temperature as the outdoor air temperature falls) or, preferably, discriminator logic from the control devices.

15.4.16 LOAD CONTROL FOR CHILLED-WATER SYSTEMS

Central station cooling equipment producing chilled water shall be controlled by a signal from a sensor mounted in the return chilled-water piping or, preferably, in the leaving chilled-water piping; this signal modulates the chiller to control chilled-water supply. Central station cooling equipment shall be provided with controls to limit the current draw of the cooling equipment in periods of high electrical demand.

When appropriate, additional controls and sensors may be added to the central chilled-water system to provide chilled water to laboratory equipment that may require it. In addition, provisions for supplying emergency chilled water to laboratory equipment may be required.

15.4.17 COOLING TOWER AND WATER-COOLED CONDENSER SYSTEM CONTROLS

Design of cooling tower fans shall consider use of variable-speed drives (if feasible) or two-speed motors (if feasible) and on/off controls to reduce power consumption and maintain condenser water temperature. Bypass valve control shall be provided, if required, to mix cooling tower water with condenser water in order to maintain the temperature of entering condenser water at the low limit. To decrease compressor energy use, condenser water temperature shall be allowed to float, as long as the temperature remains above the lower limit required by the chiller. The design shall provide basin temperature-sensing devices and, if the cooling tower is operated under freezing conditions, shall provide additional heat and control system components to maintain cooling tower sump water temperatures above freezing.

When appropriate, additional controls and sensors may be added to the condenser water system to provide condenser water to laboratory equipment that may require it. In addition, provisions for supplying emergency condenser water to laboratory equipment may be required.

15.4.18 CONTROL OF STEAM SYSTEMS

Each zone air handler, heating coil, and individual terminal unit shall be controlled by two-way control valves that are activated either electrically, pneumatically, or through use of self-contained liquid or wax-filled sensing elements. These control valves shall modulate the steam flow to the coil or terminal unit, according to the space temperature or the coil discharge temperature preset to meet zone temperature requirements. Steam pressure and temperature control valves shall be selected according to the requirements in the ASHRAE handbooks.

15.4.19 ENERGY MANAGEMENT SYSTEMS

Central emergency management systems shall be provided where feasible. If such integration is cost-effective, an EMS shall be combined with integral fire and smoke detection supervisory systems and lighting-control systems. An EMS shall have the capability of connecting to additional building utility systems. When use of an EMS is contemplated for the future, the design professional shall select other building system controls and instrumentation that will connect easily to the future EMS.

15.4.20 ENERGY METERING

In facilities where the energy consumption is expected to exceed 500 million British thermal units (Btu) per year, energy metering systems for all incoming electric, gas, oil, and water utilities shall be designed to be monitored and tracked by the EMS. Submetering of utilities to various buildings or equipment shall be based on project criteria or, in the absence of these, on sound engineering judgment.

15.5 Heating, Ventilation, and Air-Conditioning Systems

15.5.1 GENERAL

Selection of central station cooling systems shall be based on the LCCA procedures. Size, selection, and design shall be based on guidelines in the ASHRAE *Fundamentals*, *HVAC Systems and Equipment*, and *HVAC Applications* handbooks. Refrigeration equipment shall comply with Air-Conditioning and Refrigeration Institute (ARI) 520, ARI 550, and ARI 590. To ensure the most economical operation, the number and size of central station cooling units shall be based on the annual estimated partial-load operation of the plant.

- The project design criteria shall provide direction on installed standby chiller capacity. Wherever possible, the central station chilled-water equipment shall be designed into the chilled-water distribution systems as part of a primary-secondary loop system maintaining the chilled-water inlet temperature below a maximum predetermined value; ideally, the central station cooling equipment will be the secondary portion of the loop.
- Temperature-critical areas (such as laboratories and computer centers), as determined by project criteria, shall be provided with independent refrigeration systems with backup systems if the areas are involved with vital programs. Use of off-peak cooling systems shall be considered in areas that have high electric peak demand charges.

15.5.2 AIR-CONDITIONING SYSTEMS

The refrigerant in air-conditioning systems should be recycled during servicing, as required under Section 608 of the Clean Air Act. Existing chillers should be retrofitted or replaced with CFC-free refrigerant systems. Except as set forth herein, all air-conditioning and ventilating systems for the handling of air that is not contaminated with flammables or explosive vapors or dust shall conform to the requirements of NFPA 90A.

15.5.2.1 AIR DISTRIBUTION

No vertical portion of the exit facilities or protected hallways leading from the vertical exit to the outside of the building shall be used for the normal distribution or return of air.

15.5.2.2 SMOKE CONTROL SYSTEMS

Smoke control systems shall be provided in all facilities that are 12 stories tall or taller. Smoke control systems shall be provided in accordance with NFPA 92A.

15.5.2.3 SHAFT CONSTRUCTION

The construction of shafts containing, or used as, vertical ducts shall comply with the vertical shaft requirements contained in Section 13, Special Construction, of this Manual and Chapter 2, Basic Fire Safety Standards, of the *Safety Manual*.

15.5.2.4 AUTOMATIC FIRE DOORS AND DAMPERS

Automatic fire doors and fire dampers shall be provided in the air distribution and air return and exhaust systems per the requirements of NFPA 90A and Section 8, Doors and Windows, of this Manual, except where doors and dampers are omitted in accordance with other standards (e.g., no fire dampers are to be provided in fume hood exhaust ducts, per NFPA 45).

15.5.3 WATER CHILLERS

The selection of either centrifugal, reciprocating, helical, rotary-screw, absorption, or steam-powered chillers shall be based on coefficients of performance under full-load and partial-load conditions; these coefficients are used in analysis done by LCCA methods. LCCA shall also consider the pumping-energy burdens on the chilled-water and condenser water system as part of the evaluation. Compression refrigeration machines shall be designed with the safety controls, relief valves, and rupture disks noted below, and design shall be in compliance with the procedures prescribed by ASHRAE standard 15 and Underwriters Laboratories Inc. (UL) 207.

- Controls shall include, at a minimum:
 - High-discharge refrigerant pressure cutout switch
 - Low-evaporator refrigerant pressure or temperature cutout switch
 - High and low oil pressure switches
 - Chilled-water flow interlock switch
 - Condenser water flow interlock switch (on water-cooled equipment)
 - Chilled-water low-temperature cutout switch.
- Centrifugal compressors shall be designed to operate with inlet control or variable-speed control for capacity modulation. Units shall be capable of modulating to 10 percent of design capacity without surge. Reciprocating compressors shall be designed for capacity control by cylinder unloading. Designs using hot-gas bypass control of compressors for capacity modulation shall not be used except when capacity modulation is required at conditions below 10 percent of the rated load. Compressor motors for refrigeration equipment shall be selected in compliance with all requirements of the National Electrical Code (NEC).
- Absorption refrigeration machines shall be provided with the following safety controls, at a minimum:
 - Condenser water flow switch
 - Chilled-water flow switch
 - Evaporation refrigerant level switch
 - Generator high-temperature limit switch (gas-fired units)
 - Generator shell bursting disc (high-temperature water or steam)
 - Concentration limit controls.
- Liquid coolers (evaporators) shall be designed to meet the design pressure, material, welding, testing, and relief requirements of ASHRAE standard 15 and the American Society of Mechanical Engineers

(ASME) Boiler and Pressure Vessel Code, Section VIII. Evaporators shall be selected according to the requirements of ASHRAE standard 24-78.

15.5.4 CONDENSERS/CONDENSING UNITS

Water-cooled condensers shall comply with ASHRAE standard 15 and ASME Boiler and Pressure Vessel Code, Section VIII. Water-cooled condenser shells and tubes shall have removable heads, if available, to allow tube cleaning. The use of marine water boxes on the condenser shall be considered for ease of tube cleaning.

Air-cooled condensers and condensing units shall meet the standard rating and testing requirements of ARI 460 and ASHRAE standard 20. Air-cooled condenser intakes shall be located away from any obstructions that will restrict airflow. Air-cooled equipment shall be located away from noise-sensitive areas, and air-cooled condensers shall have refrigerant low-head-pressure control to maintain satisfactory operation during light loading.

15.5.5 COOLING TOWERS

Cooling towers shall be located and placed to avoid problems with water drift and deposition of water treatment chemicals. Cooling towers shall have ample clearance from any obstructions that would restrict airflow, cause recirculation of discharge air, or inhibit maintenance.

15.5.5.1 Cooling tower acceptance and factory rating tests shall be conducted in accordance with Cooling Tower Institute (CTI) Bulletin ATC-105.

15.5.5.2 An automatically controlled water-bleed shall be designed for all cooling towers. A cooling tower water treatment program should be selected by a specialist.

15.5.5.3 Cooling towers shall have sump water heating systems if they will operate during freezing weather.

15.5.5.4 Combustible casings are acceptable in cooling towers, provided that the fill and drift eliminators are noncombustible. (Polyvinyl chloride [PVC] and fire-retardant-treated, fiberglass-reinforced plastic are classified as combustible.) In determining cooling tower requirements, the definitions of combustible and noncombustible in NFPA 214 shall be used. Cooling towers with more than 2,000 cubic feet of a combustible fill shall be provided with an automatic sprinkler system, designed in accordance with NFPA 214, when any of the following conditions exist:

- The continued operation of the cooling tower is essential to the operations in the area it services.
- The building is totally sprinkler protected.
- A fire in the cooling tower could cause structural damage or other severe fire exposure to the building.
- The value of the cooling tower is five or more times the cost of installing the sprinkler protection. The cost of the sprinkler protection shall include all factors involved, such as the sprinkler piping distribution system, the heat-sensing system, the control valve, and any special water supplies or extension of water supplies required.

15.5.5.5 Cooling towers with airstreams that pass through water shall have the water treated with an EPA-approved biocide to control etiological organisms or any chlorinated hydrocarbon pesticides, herbicides, or other chemicals that may be present because of local conditions. A maintenance program must be established to ensure continued, effective operation of these treatment systems.

15.5.6 BUILDING HEATING SYSTEMS

This subsection applies to heat-generating equipment or heat-transfer equipment and accessories located in individual buildings. The project criteria shall provide direction on factors to be considered in the selection of heating system capacity; such factors include redundancy, future expansion or building

modification, thermal storage or solar assistance, and other project-specific considerations. If maintaining the building design temperature is critical, a stand-alone heating system shall be designed with backup capability and with no dependence on other facility systems.

15.5.6.1 Where buildings are connected to the central plant heat generation/distribution system, one of the following shall be provided:

- Steam-to-building hot water heat exchanger
- High-temperature water (HTW)–to-building hot water heat exchanger
- Steam-pressure reducing station.

15.5.6.2 For space heating by hot water, conversion of the central heating plant steam or HTW shall provide a maximum heating-water supply temperature of 200°F for building terminal units. For space heating by steam, the building steam supply pressure shall be reduced to 15 pounds per square inch gauge (psig) unless a higher supply pressure is needed for process requirements. For process-related or other high temperature requirements, the project criteria shall indicate the capacities and the temperature and pressure requirements. For facilities with a central plant condensate return system, a condensate receiver with duplex pumps shall be specified. Steam-to-hot-water or HTW-to-building heating water converters shall be selected on the basis of design criteria contained in the *ASHRAE Handbook of HVAC Systems and Equipment* and *ASHRAE HVAC Applications Handbook*.

15.5.6.3 The use of direct and indirect gas-fired units, electric heating, heat pumps (air-cooled and water-cooled), low-temperature gas infrared heating, and hot-water radiant heating and hot-water distribution to terminal units, shall be considered, with selection based on the building type, the facility preference, and LCCA. Office buildings, and particularly buildings with occupants sitting near fenestration, shall be designed with perimeter finned-tube radiation heating systems or other perimeter heating systems.

- If the selected heating fuel is fuel oil, storage tanks, installed in accordance with national, state, and local EPA regulations, shall provide 30 days of full heating capacity. Each tank shall be fully trimmed for safety and operating conditions and shall include a remote level gauge. Tanks shall comply with NFPA 30 requirements.

15.5.7 HEATING EQUIPMENT

Furnaces and boilers for central heating systems shall be enclosed in a room with 2-hour fire-rated walls, floors, and ceilings, and with openings protected by automatic or self-closing 1½-hour fire doors. For small units consisting of a single furnace operating a hot air system or a boiler not exceeding 15 psi pressure or a rating of 10 bhp, a 1-hour fire-rated enclosure is permissible.

15.5.7.1 STANDARDS

Heating equipment will comply with the following standards, except where noted otherwise:

- Oil-fired—NFPA 31
- Gas-fired—NFPA 54
- Liquefied petroleum gas-fired—NFPA 58
- Liquefied natural gas-fired—NFPA 59A.

15.5.7.2 FUEL STORAGE

Where liquid fuel is used, a recessed floor or curb shall be provided, with ramps at the openings. The height of the recess or curb shall be sufficient to contain all the fuel in case the tank or container ruptures.

15.5.7.3 SHOP OPERATIONS

Shop, storage, and other operations that involve flammable or combustible materials and are not directly related to the operations in the furnace or boiler rooms shall be located elsewhere unless the furnace or boiler room is sprinkler protected. Incidental operations that do not utilize significant amounts of flammable materials are allowed in furnace or boiler rooms if proper separations are maintained between combustible materials and ignition sources (e.g., boiler equipment).

15.5.7.4 BURNERS

Regardless of size, burners on suspended oil-fired heaters shall be provided with flame supervision that will ensure shutdown in not more than 4 seconds if flame failure occurs or trial for ignition does not establish a flame.

15.5.7.5 SPACE HEATERS

When used in approved locations, space heaters and portable heaters shall be approved or listed by the American Gas Association, UL, or another nationally recognized testing authority. They shall be installed in accordance with all of the requirements of the manufacturer, the facility owner, and the EPA Safety, Health and Environmental Management Manager involved. Any combustion space heater should be directly vented to the outside by a flue to avoid the contamination of the occupied space with combustion gases. Portable liquid-fueled space heaters shall not be used in EPA-occupied spaces.

15.5.7.6 GAS PIPING

Gas piping entry into the building shall be protected against breakage due to settling, vibration, or, where appropriate, seismic activity. Where practical, piping shall be brought in above grade and provided with a swing joint before it enters the building. Where it is necessary for gas piping to enter a building below ground, the physical arrangement shall be such that a break in the gas line due to settling or other causes at or near the point of entry cannot result in the free flow of gas into the building. Local gas utility and code requirements shall be followed.

15.5.7.7 GAS METER REGULATORS

To avoid placing any strain on the gas piping, any meters, regulators, or similar attachments shall be adequately supported. Any vents or rupture discs on the equipment shall be vented to the outside of the building.

15.5.7.8 VALVES

Earthquake-sensitive shutoff valves shall be provided for each gas entry, where applicable.

15.5.7.9 PIPING LOCATION

Gas piping shall not be run in any space between a structural member and its fireproofing.

15.5.7.10 GAS METER ROOMS

Gas meter rooms shall be vented in a way that removes any leaked gas without transporting it through the structure.

15.5.7.11 FIRE-RESISTANT SHAFTS OR CONDUIT

For large-capacity gas services (piping greater than 3-inch diameter at 4 inches of water pressure head or any other size with equivalent or greater delivery capabilities) within a building, the piping shall be enclosed in fire-resistive shafts and vented directly to the outside at top and bottom. Any horizontal runs of the gas pipe shall be enclosed in a conduit or chase, also directly vented at each end to the exterior or to the vented vertical shaft. Automatic gas detection and automatic shutoff shall be provided.

15.5.8 WATER DISTRIBUTION SYSTEMS

Economical pipe sizes shall be selected for chilled water, hot water, condenser water, boiler feed, and condensate return systems based on the allowable pressure drop, flow rate, and pump selection criteria prescribed in the *ASHRAE Fundamentals*, *HVAC Systems and Equipment*, and *HVAC Applications*.

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handbooks. Insulation shall be provided on all water distribution piping and system components. Strainers shall be provided at the suction side of each pump and of each control valve. Flexible connectors shall be specified for installation on the suction and discharge piping of base-mounted end-suction type pumps and on electronically driven chillers.

- Check valves and balancing valves, or combination check-shutoff-balance valves, shall be installed in the discharge piping of all pumps operating in parallel pumping systems. Balancing valves shall be installed in the discharge piping of all pump systems.
- Service valves shall be installed in the suction and discharge piping of all major pieces of equipment. Balancing valves shall be provided in the discharge piping of all coils and in central station cooling equipment.
- An air elimination pressure control, venting, and automatic filling system (with backflow prevention) shall be provided for each hot-water and chilled-water distribution system; water treatment injection should also be provided, if required.
- Expansion or compression tanks and fill piping connections shall be located on the suction side of the distribution system pump or pumps. Expansion tanks and air separation devices shall be sized according to the methods in the *ASHRAE Handbook of HVAC and Equipment*, and specified in accordance with the requirements of ASME B31.1. Gauge glasses, drain valves, and vent valves shall be provided for all expansion tank systems.
- Water treatment design information for chilled-water, hot-water, and boiler feed water systems shall be provided by a specialist and based on project criteria (tested water condition).

15.5.9 PUMPS AND PUMPING SYSTEMS

Pumps for chilled-water, hot-water, condenser water, boiler feed water, and condensate systems shall be centrifugal-type pumps and shall be selected on the basis of the criteria in the ASHRAE handbooks. Materials, types of seals, bearings, wear rings, shafts, and other features shall be selected on the basis of specific system requirements. Use of primary-secondary type pumping systems and high-efficiency motors shall be considered for pumps for all hot-water and chilled-water distribution systems.

- For systems where system pumping horsepower requirements are greater than 20 bhp, use of variable-speed drives or parallel-pumping arrangement shall be considered.
- Standby pumps shall be provided for all systems, as dictated by project-specific criteria.

15.5.10 STEAM DISTRIBUTION SYSTEMS

All steam piping shall comply with ASME B31.1 and shall be at least Schedule 40 black steel. Fittings, valves, and accessories shall be selected on the basis of pipe size and temperature and pressure conditions.

15.5.11 AIR-HANDLING AND AIR DISTRIBUTION SYSTEMS

Air-handling equipment and air distribution systems shall be sized to optimize performance, initial cost, and operating and maintenance costs over the life of the system. All air-handling system equipment (e.g., fans, terminal units, air-handling units) shall be provided with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the noise criteria (NC) levels recommended for various types of spaces and the vibration criteria listed in the ASHRAE handbooks. Where air-handling equipment and air distribution systems cannot meet these requirements, sound, and vibration-attenuation devices shall be installed in the air-handling systems.

- 15.5.11.1 The HVAC system for the sections of the laboratory building (including corridors) where the laboratory and laboratory support rooms are located shall be a one-pass air system. These sections of the laboratory

building, as well as the hazardous chemical storage building, shall have an independent air-handling unit(s). The general exhaust and special instrument canopy hoods in these sections and in the hazardous chemical storage building shall be 100 percent constant volume at all times.

Minimum airflow requirements to be maintained are: 250 cfm with four air changes per hour for an unoccupied laboratory, or calculated to prevent concentration of volatile vapors at or above 25 percent of their lower flammable/explosive limit (LEL) within the hood; and not less than eight air changes per hour during occupied hours, while maintaining negative pressure within laboratories relative to adjacent corridors and nonlaboratory spaces. Specifications for controls and monitoring devices for exhaust and air-handling units should be consistent with these minimum airflow requirements.

The setback mechanism shall provide a low-speed operations setting for the fan motors of air-handling unit(s) and fume hoods in a particular zone. Fan motors can be simultaneously activated. The setback mechanism shall be designed to provide 250 cfm minimum for 6-foot and smaller laboratory hoods; it shall provide room temperatures of approximately 55°F in the winter and approximately 85°F in the summer unless other, overriding temperature requirements are specifically stated. The HVAC system(s) nighttime setback shall be controlled by a timer connected to the energy management control system of the building. The fume hood face velocity reduction of 25 percent of full open-flow air volume (100 fpm hood face velocity) and the general exhaust and special canopy hood operation at 100 percent airflow are to be balanced by an appropriate reduction in supply air (air-handling unit) fan speed in order to maintain negative pressure in the laboratory and laboratory support rooms with respect to the hallways.

Room exhaust systems shall, at all times, be capable of eliminating concentrations of fumes, odors, heat, and moisture. HVAC design, materials, and installation shall minimize the occurrence of molds, mildew, fungi, and microbial agents in the system. The combined noise level generated by mechanical and electrical building equipment and fume hoods should not exceed 70 decibels [dBA] at the face of the hoods (with the systems operating) or 55 dBA elsewhere.

The average face velocity shall be 100 fpm for all sash heights up to and including 80 percent open. Operating sash heights of less than 100 percent open require installations of sash stops and audible and visual alarms to warn operators of less than 100 fpm velocities.

15.5.11.2 Use of a VAV mechanical ventilation system is permitted if the following design and installation criteria are achieved.

- The system must be able to consistently provide 100 fpm average face velocity for conventional laboratory fume hoods irrespective of face opening setting.
- Fume hood systems must pass the performance test outlined in the *Procedures Manual for Certifying Laboratory Fume Hoods To Meet EPA Standard*. This test requires an average face velocity of 100 fpm.
- Of particular concern is the containment of a tracer test or smoke stick when the sash is opened and closed. Some VAV systems have unacceptable delays in the supply and exhaust motors in response to changes in the sash height. This will cause the backflow of contaminants into the work space and the temporary loss of negative pressure in the laboratory space relative to corridors and other adjacent spaces.
- In addition to avoiding these unacceptable conditions, a VAV system must maintain a minimal flow of air within the hood and ductwork to purge gases, vapors, and other substances; avoid condensation, impaction, and deposition in the ductwork; and achieve sufficient stack velocity so that

the contaminated airstream clears the building and does not reenter the building along with supply air.

Refer to subsection 15.5.11.1 for minimum airflow requirements.

15.5.12 FANS/MOTORS

Fans shall be designed and specified to ensure stable, nonpulsing aerodynamic operation in the range of operation, over varying speeds. Fans with motors of 20 horsepower (hp) or less shall be designed with adjustable motor pulley sheaves to assist in air balancing of systems. Fans with motors of greater than 20 hp shall use fixed (nonadjustable) drives that can be adjusted by using fixed motor pulley sheaves of different diameters. Supply air-handling units and return air fans in VAV systems shall control capacity through the use of variable-speed drives, inlet vanes, or scroll bypass dampers. All fans shall comply with AMCA standard 210, ASHRAE standard 51, and the ASHRAE *Handbook of HVAC Systems and Equipment*.

- Fans shall be located within the ductwork system, in accordance with the requirements of AMCA Publication 201. Motors shall be sized according to properly calculated bhp fan requirements and shall not use oversized fans and motors to meet future capacity needs unless so directed by the project criteria. Fan construction materials shall be selected on the basis of corrosion resistance and cost. Spark-resistant construction shall be used where required by NFPA. All fans and accessories shall be designed and specified to meet all smoke and flame spread requirements of NFPA 255. Fans used in exhaust systems of fume hoods shall also be of the noiseless type and shall be corrosion-resistant to the fumes generated in the hood.
- Smoke detectors for automatic control in air distribution systems shall be located in accordance with the requirements of NFPA 90A, Chapter 4.

15.5.13 COILS

Heating and cooling coils shall comply with ARI 410. Heating and cooling coil selection shall comply with the guidelines in the ASHRAE *Handbook of Fundamentals* and the ASHRAE *Handbook of HVAC Systems and Equipment*. Coil manufacturers shall certify coil performance by ARI certification or provide written certification from a nationally recognized independent testing firm that coil performance is in accordance with ARI 410.

- Heating and cooling coils shall be composed of materials appropriate for the corrosive atmosphere in which they operate. Cooling coils shall be designed with a maximum face velocity of 550 fpm. Coils designed with face velocities exceeding 500 fpm shall have features that prevent condensate carryover or use moisture eliminators. Coils shall have a drain feature.
- Recirculating air systems designed for outside-air winter temperatures below freezing shall have a preheat coil, located either in the outside air intake or in the mixed-air stream upstream of the cooling coil, unless the theoretical mixed-air temperature is calculated to be above 35°F. In this case, the preheat coils may be omitted if adequate baffling is provided to guarantee positive mixing of the return and outdoor air. Preheat coils shall be designed to maintain discharge air temperature without modulation of the steam or hot-water flow through use of modulating face dampers and bypass dampers. In moderate climates where the method has been proved to be reliable and there is no concern about coil freeze-up, steam modulation may be used for control of steam coils.

15.5.14 DUCTS

Ducts shall conform to the requirements of NFPA 90A. Exhaust ductwork for laboratories with fume hoods shall be constructed with welded longitudinal seams and welded transverse joints, or equivalent construction, in accordance with the requirements of Section 6, Ductwork, of American National Standard (ANSI/AIHA) Z9.5-1992. Any duct linings or coverings shall be of noncombustible construction. The total

assembly of the duct lining, including adhesive and any coatings or additives involved, shall have an interior finish rating of Class A (flame spread 0-25, smoke developed 0-450). Use of porous duct liners that can collect dirt and moisture contributes to indoor air quality problems. The use of such liners should be avoided and should not be considered for new construction. Where such liners are already in use, and particularly in areas close to humidification or dehumidification (cooling) equipment, provisions shall be made to protect the lining from dirt and moisture contamination.

- Duct smoke detectors, as described under Section 16, Electrical Requirements, of this Manual shall be installed in accordance with NFPA 90A requirements.

15.5.15 WALK-IN ENVIRONMENTAL AND COLD STORAGE ROOMS

Walk-in environmental rooms are rooms in which temperature and/or humidity is controlled at a single set condition within specified tolerances regardless of activity in the room. In determining the appropriate room temperature, uniformity, and gradient, the design professional should discuss heat loads (in terms of process loads and ventilation requirements) with the end user. Walk-in environmental rooms shall be capable of maintaining a 4°C room temperature with a uniformity of $\pm 0.5^\circ\text{C}$ and a maximum gradient of 1°C, unless otherwise specified in the program requirements. A walk-in cold storage room shall be capable of maintaining a minus 20°C room temperature with a uniformity of $\pm 1^\circ\text{C}$ and a maximum gradient of 3°C, unless otherwise specified. Rooms shall feature temperature displays visible from a contiguous hallway and shall be capable of producing a continuous record of temperature. Alarm systems with manual override capability shall be provided to advise room operators of fault conditions. Doors to rooms shall be provided with a locking mechanism capable of release at all times from the room interior whether or not the door is locked. Walk-in environmental and cold storage spaces shall include shelving. Walk-in coolers are considered enclosed spaces and require automatic fire sprinkler protection inside them.

A separate refrigeration system shall be provided for these rooms. If refrigeration is provided by the main building's chilled-water system, a backup self-contained system shall also be provided.

15.5.16 CENTRAL PLANT HEAT GENERATION AND DISTRIBUTION

The following criteria shall be applied in the planning and design of steam and HTW generation and distribution systems and of cogeneration facilities.

15.5.16.1 FACILITY SIZING

The design professional shall consider creating a plant design that can be easily expanded to meet potential future loads in addition to meeting confirmed near-term loads. Load computations to establish boiler capacity shall be based on the building design heating load, as determined in conformance with the ASHRAE *Handbook of Fundamentals*, plus process heating loads (if any) and an allowance for piping plants. The process heat losses shall be investigated during the design stage to determine whether heat can be recovered, thereby reducing the boiler load.

- Modular boiler installation shall be considered for all applications in order to maintain a high operating plant efficiency throughout the year. The number and size of the boilers shall be based on the number of operable hours at full and partial load operation, the turn-down ratio of the boiler being considered, efficiency at partial loads, and year-round process or summer loads. Use of a baseload boiler shall be considered when a year-round process demand exists. The system shall be designed to satisfy peak demand by operating over its maximum rating for short periods of time.
- The possibility of operating small local boilers rather than the central plant to satisfy summer loads shall also be considered. Sufficient capacity shall be furnished to allow one boiler to be down for inspection or maintenance or to be on standby while the remaining boiler(s) maintain normal operations.

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- The generating facilities shall be so located as to allow efficient steam/hot-water distribution throughout the site and to allow for future expansion of the generating and distribution system. The facility location shall also be chosen to take advantage of prevailing winds and to minimize problems associated with the following:
 - Noise
 - Dirt
 - Air pollution
 - Harmful effects on adjacent property owners
 - Accommodation of fuel deliveries and storage.
- The option of installing one or more satellite boiler facilities rather than a single central boiler complex shall be evaluated when one or more of the following conditions exist:
 - An extensive distribution system connecting several separate steam users is required.
 - Requirements exist for several different steam pressures.
 - Variable steam loadings exist with respect to time or quantity.
- The use of a cogeneration plant as a possible alternative shall be considered in the planning of any large steam generation facility. The feasibility of cogeneration with HTW or HTW boilers or HTW-to-steam generators shall be considered. In determining the feasibility of cogeneration, the following factors shall be considered:
 - Energy demand and cost, peak load, average load, seasonal variations, and utility rate structures.
 - Regulatory concerns: Public Utility Regulatory Policies Act (PURPA), relevant environmental regulations, and current local regulations.
- Cogeneration plants shall be sized to accommodate existing loads.

15.5.16.2 STEAM AND HIGH-TEMPERATURE WATER GENERATION

All boilers shall comply with the ASME Boiler and Pressure Vessel Code.

- In determining whether to select a steam or an HTW system, the following factors shall be considered:
 - Whether the system will be operated intermittently or continuously
 - Whether fast response to significant load variation is important
 - Pumping costs
 - Length, size, and configuration of required piping
 - The possibility of using HTW to generate the steam at its point of use, in a facility where only a few processes require steam.
- Steam boilers shall be designed to provide dry, saturated steam unless the economics of electricity generation, meeting specific process requirements, or accommodating extensive distribution systems necessitates use of superheated steam. If required for process, the use of high-pressure satellite boilers located close to the process shall be considered in lieu of distribution of high-pressure steam.
- An HTW system is a system that generates heating or process water with a temperature above 300°F. HTW boilers shall be of the controlled forced-circulation type, specifically designed for high-temperature water service. Because of costs associated with high-pressure pipe, valves, and fittings, HTW systems should not be designed for higher temperatures and pressures than are absolutely necessary.

- In a gas-pressurized HTW system, an inert gas, such as nitrogen, shall be used and the pressurizing tank shall be installed vertically to reduce the area of contact between gas and water, thus reducing the absorption of gas into the liquid. Gas-pressurized systems should be maintained at a pressure that is well above the pressure at which the HTW will flash to steam. Pump pressurization is generally restricted to small process heating systems. In larger HTW systems, pump pressurization can be combined with gas pressurization.

15.5.16.3 CIRCULATION PUMPS

In selecting and installing circulation pumps, energy efficiency shall be emphasized. Consideration shall be given to the use of variable-speed circulation pumps. In steam-pressurized systems, circulating pumps shall be located in the supply lines to maintain pressure above the flashpoint of the hottest water in the distribution system. A mixing connection that allows some of the coil return water to pass into the supply line at the pump suction shall be provided to safeguard against flashing or cavitation at the pump(s). In a gas-pressurized HTW system, the circulating pumps may be installed in either the supply lines or the return lines.

15.5.16.4 FUEL STORAGE AND HANDLING SYSTEMS

Control, containment, and treatment of rainwater runoff from coal storage yards shall comply with effluent guidelines and standards for steam-electric power-generating point sources (40 CFR Part 423). The relative economy of a central natural gas-fired plant compared with a gas distribution system serving the individual requirements of each building shall be considered. The long-range availability of the gas supply and the possible need for a secondary fuel shall be established. The economics of interruptible versus uninterruptible gas service relative to availability of secondary fuel shall be considered.

- Fully automatic mechanical-firing equipment and mechanical draft equipment shall be provided. Mechanical-firing equipment capable of developing 100 percent to 125 percent of the boiler capacity shall be specified.
- Ash-handling systems shall comply with Federal Construction Council Technical Report No. 51, Chapter III, Section 3.1. Land availability for storage or disposal, water availability, nearness to residential areas, the possibility of selling the ash as a means of disposal, and environmental regulations shall be considered. Collection and treatment of ash-carrying liquid effluents shall comply with 40 CFR Part 423.
- Stationary internal combustion engines, such as gasoline- or diesel-powered generators or fire pumps, shall conform to the requirements of NFPA 37.
- The use of underground tanks shall be avoided.

15.5.16.5 BOILER WATER TREATMENT

Boiler water treatment shall be provided to prevent deposits on or corrosion of internal boiler surfaces and to prevent the carryover of boiler water solids into the steam. A boiler water treatment specialist shall be consulted to determine appropriate treatment measures. Water quality measures for the steam plant and for other site process water users should be coordinated. The design of the plant shall provide for daily sampling to determine internal water conditions. Provisions shall be made for introducing treatment chemicals into the feed water. The plant shall contain adequate space and equipment for storing, handling, and mixing chemicals. Continuous versus intermittent blowdown operations shall be considered to determine which system will keep the concentration of total solids within acceptable limits. For continuous blowdown operations, the economics of installing a heat recovery system shall be considered.

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- A minimum of two boiler feed pumps, each sized to handle the peak load, shall be provided to allow one pump to be out of service without affecting facility operations. Pumps shall be equipped with automatic controls that regulate feed water flow to maintain the required water level and with a relief valve. Relief valves shall be preset to lift at a lower pressure than the boiler safety valve setting plus static and friction heads.

15.5.16.6 BOILER ROOM CONTROLS AND INSTRUMENTATION

Boiler plant instrumentation and control panels shall include devices for monitoring the combustion process and consoles in equipment in which such devices are mounted. Boiler room controls and instrumentation shall comply with the appropriate standard from among NFPA 8501, NFPA 8502, NFPA 8503, NFPA 8504, NFPA 8505, and NFPA 8506.

15.5.16.7 PLANT INSULATION

All hot surfaces within 7 feet of the plant floor, or on any catwalk, shall be insulated to prevent surface temperatures above 60°C (where contact would be unintentional and unlikely) and above 49°C (where contact is likely or necessary for equipment operation). Insulation shall be in accordance with the manufacturer's recommendations and the ASHRAE *Handbook of Fundamentals*.

15.5.16.8 STEAM AND HIGH-TEMPERATURE WATER DISTRIBUTION

Steam and HTW distributions systems shall be sized to accommodate, without extensive modification, any future expansion anticipated in the project criteria.

- When aboveground steam or HTW distribution systems are to be constructed, pipe shall be installed on concrete pedestals, on concrete/steel stanchions, or on poles. Where piping crosses over roadways, a minimum of 14 feet of clearance shall be provided.
- Provisions shall be made for expansion and contraction in the piping system. Expansion loops shall be provided where space allows. Where space does not allow expansion loops, expansion joints may be used. Piping shall comply with ASME B31.1
- Unless economics dictates otherwise, steam shall be supplied to the distribution system at the lowest pressure that will adequately serve the connected load. The economics of higher pressure distribution shall be considered. Processes requiring higher pressures shall be serviced, where practical, by a separate section of the distribution system to avoid operating the entire system at higher pressures than necessary.
- Warm-up bypass valves shall be provided at all shutoff valves in steam distribution lines. Steam velocities shall be selected for the type of service being considered but shall not exceed 10,000 fpm.
- Steam and condensate pipe shall, where possible, be graded at a minimum of 1 inch in 40 feet in the direction of flow. Drip stations and steam traps shall be provided at all low points in steam lines.
- To ensure tightness of the steam system, all joints to valves and fittings that are larger than 1.25 inches shall be welded, except in the boiler house, where flanges shall be used to facilitate maintenance of equipment, connections, and valves.
- HTW piping shall be sized for an average velocity of 5 feet per second, a maximum velocity of 10 feet per second, and a minimum velocity of 2 feet per second. To ensure tightness of the HTW system, all joints to valves and fittings that are larger than 1.25 inches shall be welded, except in the boiler house, where flanges shall be used to facilitate maintenance of equipment, connections, and valves.

- Unlike steam piping, HTW piping may follow the natural terrain; however, proper provisions shall be made for draining and venting the piping.

15.5.16.9 PIPING INSULATION

Insulation containing asbestos is prohibited. The possibility that water infiltration will cause physical damage to, or loss of thermal characteristics of, underground pipe insulation shall be considered in the selection of insulation. All insulation installed aboveground, in tunnels, and in manholes shall be provided with either a metal jacket, either factory or field installed, or a hard cement finish.

15.6 Load Calculations

15.6.1 GENERAL

Load calculations shall be based on data and procedures outlined in the ASHRAE handbooks and shall be in accordance with the conditions specified in this Manual.

15.6.2 SUBMISSION

A complete set of calculations shall be submitted showing building heating and cooling loads and equipment capacity requirements.

15.6.3 DESIGN

Load calculations may be performed manually or by a nationally recognized computer-based load program. Specialty programs that are not recognized must be approved by the contracting officer prior to use.

15.6.4 AIR VOLUME/EXCHANGE

For laboratory spaces, the specific volume of air required to achieve a predetermined air exchange rate shall be dictated by the type of work being performed in the laboratory.

15.6.5 AUXILIARY AIR

If a separate auxiliary air system is provided, the auxiliary air must be heated and cooled to within the room dry bulb temperature. Auxiliary air shall not exceed 70 percent of total fume hood exhaust requirements.

15.7 Laboratory Fume Hoods

Certification of EPA laboratory fume hoods, as constructed, manufactured, installed, and used, shall conform to current EPA requirements. The design professional, in consultation with the users of the facility, shall be responsible for selecting fume hood types and sizes that are appropriate to the hoods' intended use. The requirements of this subsection and of Chapter 5, paragraph 12, of the *Safety Manual* shall be followed. The requirements of the EPA fume hood standards, *Quantitative Performance Test for Laboratory Fume Hoods*, shall also be followed. In accordance with *Procedures Manual for Certifying Laboratory Fume Hoods To Meet EPA Standard*, fume hood face velocity must be provided at 100 linear feet per minute with a uniform face velocity profile of ± 10 percent of the average velocity with the sash fully open to provide protection from operations performed in the hood.

15.7.1 HOOD REQUIREMENTS

Certification of EPA laboratory fume hoods, as constructed, manufactured, installed, and used, shall conform to current EPA requirements. Before EPA purchases any hood model, the laboratory fume hood manufacturer, at a test facility provided by the manufacturer, and at no cost to the Government, shall certify the proper performance of the fume hood in accordance with EPA's criteria. In addition to complying with EPA's fume hood criteria, each hood shall have an ASHRAE 110 standard performance rating, as manufactured, of 4.0 AM 0.05. After the new hoods are installed, EPA requires the manufacturer to evaluate the installation and performance of the hoods prior to acceptance and use by EPA.

SHEMD is responsible for approving the certification of fume hoods. SHEMD should document the approval of all newly installed fume hoods for AEREB. A list of approved or certified hoods is available from SHEMD.

Materials used in the construction of fume hoods and of exhaust blowers shall meet corrosion-resistance standards for the chemicals used and generated in the hood, as described in the hood uses; blowers should be rated or otherwise approved for use; and plumbing fixtures and electrical outlets should meet existing codes. EPA specifications and testing procedures for checking the performance of fume hoods are available from AEREB and SHEMD.

All hoods specified in the design criteria shall have a rating of 04A AM 0.04, in accordance with the ASHRAE 110-93 fume hood test procedure, *EPA Fume Hood Procurement Manual*, and the EPA fume hood standard, *Quantitative Performance Test for Laboratory Fume Hoods*. Exhaust from fume hoods and general laboratory exhausts shall be routed to the exterior of the building at the highest part and position of the exhaust stacks to prevent entrainment of fumes at fresh-air intake points. Exhaust discharge stacks shall be at least 7 feet above the adjacent roofline and shall be so located with respect to openings and air intakes of the laboratory or adjacent buildings as to avoid reentry of the exhaust discharge. The operational exhaust discharge shall have an exhaust velocity of at least 3,000 fpm (at least 4,000 fpm is recommended) and shall conform to ANSI Z9.5. Stacks shall be designed in accordance with ASHRAE and ACGIH industrial ventilation guidelines. All fume hoods shall be installed under the manufacturer's supervision. In the case of VAV fume hoods, the hoods shall be installed under the supervision of the hood manufacturer and the room control systems manufacturer. All hoods shall be certified per EPA's certification manual prior to turnover.

- Ceiling and wall supply diffusers for the distribution of supply air in the laboratory shall be designed for a maximum air velocity of 25 fpm at 6 feet above the finished floor at the face of the hood.
- Face Velocities: Although the *Safety Manual* allows for an 80 fpm airflow, the Safety, Health and Environmental Management Program (SHEMP) contends that EPA is unable to demonstrate uninterrupted "ideal conditions" (e.g., pedestrian traffic). Therefore, EPA must design for realistic scenarios and demonstrate adequate safety at an airflow of 100 fpm (plus or minus 10 percent at any given measurement).

15.7.2 FUME HOOD EXHAUST

The design for laboratory fume hood exhaust shall be in accordance with the design criteria of NFPA 45. Provisions shall be made in the design of the laboratory supply air system for 25 percent future expansion of fume hoods beyond what is presently required to meet program design needs. Fume hoods, biological safety cabinets (BSCs), and general laboratory exhaust may be combined in a commonly manifolded exhaust duct system for blocks of hoods; however, such combined systems require the prior approval of EPA Headquarters Health and Safety Approving Officers. Provisions should be made for separate, dedicated duct and exhaust systems for special fume hood exhausts, including, but not limited to, perchloric acid hoods, high-energy radioisotope hoods, and exhausted biological safety cabinets, that cannot be combined in a commonly manifolded system.

15.7.2.1 MANIFOLDING OF FUME HOODS

In order for manifolded fume hoods to be safe, sufficient dilution of air within the ductwork must be maintained to avoid significant chemical reactions, which may result in fire, corrosion, deposition, and/or increased toxicity. Low airflows afforded by VAV may increase the potential for significant reaction. Special purpose hoods (for example, but not limited to, radioisotope hoods, glove boxes, biocabinets) should not be connected with general chemistry hoods. Hoods used for dissimilar purposes or hoods that are far apart from each other should not be manifolded. The costs and balancing of logistics for all affected hoods in the system exhaust and the supply system with each change in the

system may outweigh the advantages of manifolding hoods. (See subsection 15.7.12 below.) Perchloric acid hood exhaust ducts shall not be manifolded and shall have separate exhaust ducts.

15.7.3 CONSTANT VOLUME BYPASS-TYPE FUME HOOD

The laboratory fume hood is often an integral part of the building exhaust system. The volume of air exhausted should be constant, achieved by an airflow bypass above the sash through which room air can pass as the sash is lowered. A horizontal bottom and a vertical side airfoil must be specified and used on all hoods, and the face edges must be shaped to minimize entering air turbulence. Vertical foils on the sides also result in a slight airflow improvement by minimizing the eddies caused as air enters the hood. The work surface should be recessed three-eighths of an inch or more so that spills can be effectively contained. The front raised edge should extend just past the airfoil but not far enough to be used as a working surface near the face opening.

The bypass sizing and design must be such that the following conditions are met:

- The total airflow volume is essentially the same at all sash positions. As the sash is lowered, the face velocity increases to a rate that shall not exceed three times the design velocity for a fully open sash position.
- The bypass must provide a sight-tight barrier between the hood work space and the room when the sash is lowered.
- The bypass opening is dependent only on the operation of the sash. Selected sash configurations are listed and described below:
 - The vertical-rising fume hood sash shall be full-view type providing a clear and unobstructed side-to-side view of the fume hood interior and the service fitting connections. The sash shall be 1/4-inch laminated safety glass. The sash system shall utilize a single-weight pulley cable counterbalance system permitting one-finger operation along the length of the sash pull. The counterbalance system will hold the sash at any position without creep and will prevent sash drop in the event of malfunction or failure of a cable.
 - The combination vertical-rising and horizontal-sliding fume hood sash shall be similar in design to the vertical-rising sash configuration but with multiple horizontal sliding sashes of 1/4-inch laminated safety glass panels on multiple tracks within the vertical rising sash frame.
- The following hood models are approved for use in EPA facilities:
 - Safeaire 54L597 6-foot bench hood
 - Safeaire 554S710 5-foot walk-in hood
 - Pace-aire 54L51200 3-foot bench hood.
- The hoods listed above are constant-volume bypass hoods but can be field-converted to an auxiliary air-type hood (described below). While current EPA policy discourages the use of auxiliary air-type hoods in new construction, their use may be justified under special circumstances, such as in renovations where the existing ventilation system is inadequate and where expansion of system capacity may be mechanically unfeasible or too costly. Auxiliary air hoods are hoods that are provided with a source of air in addition to that taken from the room. It is essential that all air for these hoods be supplied from outside the hood face. Any model that introduces air behind the sash must not be used, because this arrangement reduces the control velocity at the face and could actually pressurize the work chamber if the exhaust flow is reduced (e.g., by foreign matter in fan, a broken belt, or normal wear and maintenance). Features described for the constant-volume bypass-type hood, including the bypass arrangement, are applicable to the auxiliary air hood. Auxiliary air supplies must be turned off to test

the face velocity of the hood; a readily accessible means of turning off auxiliary air electrical power will facilitate such testing.

15.7.4 VARIABLE-AIR-VOLUME (VAV) HOODS

Certification of EPA laboratory fume hoods, as constructed, manufactured, installed, and used, shall conform to current EPA requirements. The variable flow controls for the hood exhaust and those for the laboratory exhaust and supply system must be manufactured by the same company. The control manufacturer, in conjunction with the hood manufacturer, shall supervise the installation and certify that the hood and laboratory system operation is as designed. The design shall follow EPA's *Standard Chemical Laboratory Design Recommendations for VAV Fume Hoods* (contact AEREB for these design criteria). Response times for reestablishing the proper face velocity after a maximum change in sash position shall not exceed 0.8 seconds. The minimum airflow through a VAV hood must meet or exceed 250 cfm, with four room air changes per hour for an unoccupied laboratory, or must be calculated to limit the accumulation of volatile vapors within the fume hood to less than 25 percent of their lower flammable limit. The minimum airflow during occupied hours will be capable of eight room air changes per hour in the laboratory. As an alternative to relying on minimum airflows for preventing accumulation of vapors, fume hoods, whose interior may be classified as described in NEC Article 500, and appropriate electric devices and equipment within the fume hood enclosure may be used. However, the minimum flows still must be capable of maintaining the laboratories at a negative air pressure relative to adjacent corridors and nonlaboratory spaces. Refer to NFPA 45 for guidance on electrical classification of fume hood enclosures.

15.7.5 RADIOISOTOPE HOODS

Radioisotope hoods shall be similar to the fume hood types described above, except that the interior liner material shall have panels at the sides, back, top, and plenum enclosure of 18-gauge Type 302 stainless steel and structural members, reinforcements, and brackets of 16-gauge Type 302 stainless steel. The work surface should be 14-gauge Type 302 stainless steel. Joints should be fully sealed by welding or fine-line solder. The base structure should have a heavy angle frame reinforced to support 1 ton of lead brick shielding. The work surface shall be reinforced from the underside with heavy steel grating to provide the necessary strength for holding lead brick radiation-protection and/or shall be capable of supporting at least 200 pounds per square foot. To minimize radioactive emissions into the atmosphere, high-efficiency particulate aerosol (HEPA) filters should be considered as a best available control technology for radioactive isotope hoods. Guidance on the limitations, selection, and design of radioactive air-cleaning devices can be found in the *Nuclear Air Cleaning Handbook*, Energy Research and Development Administration (ERDA) 76-21, and in *Nuclear Power Plant Air Cleaning Units and Components*, ANSI/ASME N509.

15.7.6 PERCHLORIC ACID FUME HOODS

In addition to the features described for fume hoods, perchloric acid hoods must use materials that are nonreactive, acid resistant, and relatively impervious. Type 316 stainless steel with welded joints should be specified, although certain other materials may be acceptable. Corners shall be rounded to facilitate cleaning. Work surfaces shall be watertight with an integral trough at the rear for collection of wash-down water.

- Perchloric acid fume hoods shall be constant-volume bypass or auxiliary air type with an average face velocity of 100 fpm.
- A wash-down system must be provided that has spray nozzles to adequately wash the entire assembly including the blower, all ductwork, and the interior of the hood, with an easily accessible strainer to filter particulates in the water supply that might clog the nozzles. The wash-down system shall be activated immediately after the hood has been used.
- Ductwork shall be installed with a minimal amount of horizontal runs and no sharp turns; ductwork also must not be shared with any other hood.

- Exhaust fans must be of an acid-resistant, nonsparking (AMCA Standard Type A) construction. Lubrication shall be with a fluorocarbon grease only. Gaskets shall be of a tetrafluoroethylene polymer.
- Perchloric acid must never be used in hoods not specifically designed for its use. Organic materials, strong dehydrating or desiccating agents, and oxidizing or reducing materials must not be used in a hood used for perchloric acid.

15.7.7 SPECIAL PURPOSE HOODS

Special purpose hoods are defined as any hood that does not conform to the specific types described above in this subsection. Special hoods may be used for operations for which other types are not suitable (e.g., as enclosures for analytical balances, gas vents from atomic absorption, or gas chromatography units). Other applications might present opportunities for achieving contamination control with less bench space or less exhaust volume (e.g., using the hoods as special mixing stations, sinks, evaporation racks, heat sources, and ventilated worktables). Special purpose exhaust hoods shall be designed in accordance with ANSI A9.2 and NFPA 45. Appropriate applications for specific types of special purpose hoods are described below.

- Canopy Exhaust (Capture) Hoods: These shall be provided as required for the removal of heat from specific laboratory apparatus, such as furnaces, ovens, and sterilizers, or as otherwise called for in the laboratory program.
- Flexible Spot Exhausts (Snorkels): These shall be required to remove chemical fumes or heat from specific laboratory instrumentation, such as high-performance liquid chromatography (HPLC), gas chromatography/mass spectrometry (GC/MS), and atomic absorption (AA) units. Snorkels require an estimated exhaust rate of 100 to 200 cfm or a rate appropriate to the intended use.
- Gas Cabinets: Special exhaust cabinets will be required to house individual or pairs of toxic/pyrophoric gas cylinders. Leak detectors and low-exhaust flow alarms, as well as a gas purge system, shall be considered to provide for safe exchange of cylinders. Exhaust for these cabinets is estimated at 50 to 75 cfm each.

15.7.8 HORIZONTAL SASHERS

Horizontal sashes, as well as other nonstandard features (larger-than-usual opening in distillation hoods, vented sinks, hoods larger than 6 feet), may be used under the following conditions. (It should be noted that horizontal sashes may put additional demands on VAV performance.)

- A conventional hood does not meet the specific requirements of the user (this should be reflected in the “standard operating procedures”).
- The hood is used as intended by the manufacturer (i.e., the hood is not altered after installation).
- The hood passes the prepurchase performance test in accordance with the *Quantitative Performance Test for Laboratory Fume Hoods*.

15.7.9 OTHER VENTILATED ENCLOSURES

Ventilated enclosures are often required by a laboratory to help dissipate heat and ensure containment of chemical or biological airborne contaminants produced during certain work. The various types of ventilated enclosures include laminar flow hoods, biological safety cabinets, glove boxes for known toxic or hazardous materials, canopy hoods, and slot hoods for known nonhazardous materials. These types of enclosures have special design requirements for their intended uses. Ventilated devices used to control hazardous materials must be individually approved by SHEMD and AEREB. Biological safety cabinets and glove boxes shall comply with NSF 49. Ventilating devices used for removal of heat or nuisance odors must comply with the parameters set forth in *Industrial Ventilation*, published by the ACGIH.

15.7.10 FACE VELOCITIES

The use of a ventilated enclosure to contain and exhaust a contaminant is predicated on the ability to provide an airflow that is sufficient to overcome operator or other exterior influences but is not excessive. Average control velocities (velocity measured at the face of installed hood) required for fume hoods located in accordance with the room data sheets contained in Appendix C must be 100 fpm at the operating sash height. Under no circumstances can the control velocity be less than 80 fpm at any sash height. The sash shall be equipped with a control device to maintain it at the operating height (e.g., releasable sash stops); the hood shall be equipped with a device to monitor the face velocity and shall provide a visible and audible alarm when the face velocity is less than 100 fpm.

15.7.11 ANNUAL CERTIFICATION

The performance of fume hoods shall be certified annually and after any significant maintenance has been performed on the exhaust system or room air supply system. The performance certification shall be performed in accordance with EPA guidelines and the procedures prescribed by SEFA.

All fume hoods purchased by EPA shall conform to the following EPA regulations:

- The fume hood shall be in compliance with the EPA fume hood specifications for constant-volume bypass-type hoods, radioactive isotope hoods, VAV-type hoods, and percholoric acid hoods.
- The fume hood shall pass the prepurchase tests outlined in ASHRAE 110 with a performance rating of 8.0 AM 0.05.
- After installation, fume hoods shall meet the EPA certification criteria outlined in ASHRAE 110. The test shall be performed by the manufacturer, in accordance with SHEMD's annual certification guidelines, in the presence of an EPA representative. The recommended airflow rates will provide the desired worker protection for any operation that should be performed with this type of equipment. Under airflows lower than those proposed, the protection factors desired for normal conditions, such as operator movement, are uncertain. Higher flows than those proposed are not required for a good laboratory arrangement and will not improve hood performance. If the laboratory arrangement is unsatisfactory, the problem should be solved by improving the arrangement rather than by increasing hood face velocity. Increased turbulence within the hood and around the operator results when higher velocities are used.

15.7.12 EXHAUST SYSTEM

Individual exhaust systems should be provided for each fume hood when the mixing of effluents from the individual hoods is inadvisable or when the effluent must be filtered, scrubbed, washed down, or otherwise treated before discharge. Manifolding of fume hood exhausts is allowed if a single discharge point is advantageous and the air supply suitably controls comfort conditions while maintaining proper laboratory pressure conditions. Pressure in laboratories shall be maintained as negative with respect to adjacent areas. Manifolled exhaust systems should incorporate staged multiple constant volume fans with control dampers to maintain a constant static pressure in the manifold in order to ensure quick response to changing hood conditions. Variable-speed fans are permitted if they are advantageous. Manifolding of fume hoods shall meet the requirements of NFPA 45. Blowers should be rated and should be installed at the end of each duct system so that all ducts within the occupied areas of a building are maintained under negative pressure. Refer to subsection 15.7.2.1 above. Hood exhaust should be designed in accordance with the recommendations in *Industrial Ventilation*, published by ACGIH; ANSI Z9.5, American National Standard for Laboratory Ventilation; and NFPA 45. Fume hood exhaust stacks should extend a minimum of 10 feet above the adjacent roof level. Additional height may be required to properly disperse the exhaust. Exhaust stacks should provide vertical discharge of at least 3,000 fpm without caps or heads. Air intakes for the facility's HVAC system shall be located as far as possible from the exhaust stack discharges.

15.7.13 NOISE

The noise exposure at the working position in front of the hood shall not exceed 70 dBA with the system operating. Each new hood installation shall be certified as meeting this requirement before initial use and shall be recertified annually thereafter. Total room performance with respect to noise levels must not exceed the limits specified in 29 CFR §1910.95.

15.7.14 EFFLUENT CLEANING

When air-cleaning devices are required, the type is determined by the contaminant and the degree of cleaning necessary. The type of air cleaner required can vary from a simple scrubber and filters to incinerators or specially designed units. A typical cleaning system consists of a prefilter, followed by a solvent-resistant HEPA filter, followed by an activated-charcoal filter. Some analytical activities may require a different cleaning system, and all cleaning systems must be approved by AEREB and SHEMD. HEPA filters offer considerable resistance to airflow, especially when airflow is loaded with contaminants. This resistance must be considered in designing a system with HEPA filters. To maintain building air balance, laboratories shall be kept under negative pressure relative to surrounding areas and proper hood control shall be maintained. It is recommended that a compensating damper be installed with a HEPA filter so that the airflow will remain constant over the life of the filter. It is good practice to install a roughing filter ahead of a HEPA filter to prolong the life of the HEPA filter. In some situations, bag-in/bag-out filter housings should be used to minimize the spread of contaminants when the HEPA or roughing filter is changed. The pressure drop across HEPA and roughing filters should be monitored, and filters changed when necessary. The filter plenum should be located on the inlet side of the fan to allow the fan to be serviced from the clean side of a filter. It is good practice to allow a straight run of duct before the fan in order to obtain good fan performance as well as to allow for future installation of other air-cleaning equipment.

15.8 Other Equipment**15.8.1 GLOVE BOXES**

Glove boxes will be Government-furnished equipment. These ventilated enclosures are often required by laboratory personnel to ensure containment of chemical and biological airborne contaminants produced during the employee's work in the box and to prevent escape of those contaminants into the room. Such enclosures permit manual manipulations within the box by means of armholes provided with impervious gloves, which are sealed to the box at the armholes. These types of enclosures have special design requirements that are related to their intended use, and they must be individually approved by SHEMD and AEREB.

15.8.2 BIOLOGICAL SAFETY CABINETS

Laminar-flow biological safety cabinets shall have met minimum standards for cabinet classifications, as stated in NSF pamphlet 49, for personnel, environmental, and product safety and shall be identified by a distinctive NSF seal. Field recertification, performed by a competent technician and done according to the procedures outlined in NSF standard 49, will be required once the cabinet(s) is installed. Cabinet classification shall be determined during laboratory programming, in consultation with the users of the facility. These types of cabinets have special design requirements depending on their intended use (such as protecting personnel from harmful agents inside the cabinet; protecting the work product, experiment, or procedure from contaminants outside the cabinet; or protecting the laboratory environment from contaminants inside the cabinet) and must be individually approved by SHEMD and AEREB.

15.8.3 FLAMMABLE LIQUID STORAGE CABINETS

Cabinets for the storage of Class I, Class II, and Class IIIA liquids shall be provided in accordance with the design, construction, and storage capacity requirements stated in NFPA 30, Chapter 4. Venting of storage cabinets is not required for fire protection purposes, but venting may be required to comply with local codes or authorities having jurisdiction.

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- If cabinet venting is required, the cabinet shall be vented to the outside as recommended by the unit manufacturer and in a manner that will not compromise the specified performance of the cabinet. The cabinet shall be vented from the bottom with makeup air supplied at the top. Mechanical exhaust ventilation should be provided at a rate of 50 cfm and should comply with NFPA 91, standard for Exhaust Systems for Air Conveying of Materials. Manifolding the vents of multiple storage cabinets is not recommended.
- Nonvented cabinets shall be sealed with the bungs supplied with the cabinet or with bungs specified by the manufacturer of the cabinet.

15.8.4 LABORATORY SERVICE FITTINGS

Laboratory service fittings for each laboratory space are specified in the room data sheets and shall be compatible with their intended use. All service valves, fittings, and accessories shall be of cast brass with a minimum copper content of 85 percent except for items that are to be brass-forged or bar stock. All service valves, fittings, and accessories shall be especially designed for laboratory use. All laboratory service fittings shall have an acid-resisting and solvent-resisting clear plastic coating applied over a clean, polished, chrome-plated surface. Service fittings at fume hoods shall have an acid-resistant and solvent-resistant plastic coating applied over a fine sandblasted surface, properly cleaned.

15.9 Air Filtration and Exhaust Systems

15.9.1 DRY FILTRATION

Air-cleaning equipment for ductwork and for equipment installation shall be easily removable, serviceable, and maintainable. Air-cleaning equipment shall have face velocities as recommended by the filter manufacturer in order to achieve the specified efficiency at the lowest possible pressure drop. Filters shall be constructed of noncombustible materials that meet the requirements of UL 900, Class I. Air filters shall be located on the suction side of fans and coils and in other special locations as required for air treatment. Air-filter pressure drop gauges of the diaphragm-actuated dial type (preferred) or the inclined manometer type shall be located on all filter assemblies except small fan coils and fan-powered VAV terminal units. The ASHRAE dust spot method shall be used in specifying the efficiencies required for medium-efficiency filters. Filters shall be specified, and installed for use, as prefilters, medium-efficiency filters, or high-efficiency filters. These filters shall comply with ARI 850. Prefilters are normally provided for high-efficiency filters, being either prefilters or medium-efficiency filters depending on the upstream air particle size distribution.

15.9.2 ABSOLUTE FILTRATION

Absolute filtration, where required in fume hood exhaust systems, will have an efficiency of 99.97 percent, as determined by the dioctyl phthalate (DOP) aerosol test for absolute filters, and shall satisfy ASHRAE standard 52-76. Filter housing shall be of bag-in/gas-out design.

15.9.2.1 TEST ACCESS

The design location shall facilitate in-place testing of HEPA filters, with particular attention given to plenum hardware that allows the HEPA filter bank to be tested without requiring the testing personnel to enter the plenum. Utility services shall be extended to the plenum location (e.g., electrical receptacles and compressed air) to facilitate testing work. In-place testing design requirements shall meet all the recommendations of UL 586 and ASME N510. HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life. The installation of prefilters may be omitted if an analysis of filtration requirements and consideration of the filter assembly justify omission.

15.9.2.2 FIRE PROTECTION OF HEPA FILTER ASSEMBLIES

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In providing fire protection for the HEPA filters, the design shall sufficiently separate prefilters or fire screens equipped with water spray from the HEPA filters in order to restrict impingement of moisture on the HEPA filters. Under conditions of limited separation, moisture eliminators or other means of reducing entrained moisture shall be provided. Moisture eliminators may be omitted where system design provides sufficient filter redundancy to ensure continued effluent filtration in the event of fire within any portion of the system. The HEPA filter fire protection system shall be activated in a manner consistent with the fire protection system in the room or building in which the filters are located.

15.9.3 AIR-CLEANING DEVICES FOR SPECIAL APPLICATIONS

Filters include dry-type dust collectors, wet collectors, centrifugal collectors, absorbers, oxidizers, and chemical treatment filters, which are used primarily in industrial and process-type applications associated with air or gases that have heavy dust loadings in exhaust systems or stack gas effluents. Filters shall be designed according to the requirements given in the project criteria, the ASHRAE *Handbook of HVAC Systems and Equipment* and ACGIH's *Industrial Ventilation*.

15.9.4 OPERATION

All building systems shall be designed for continuous operation, unless otherwise specified in the project criteria.

15.9.5 MAINTENANCE ACCESS

The air supply and exhaust plenums shall be designed so that such elements as motors, bearings, control valves, and steam traps are easily accessible for maintenance.

15.9.6 LOCATION OF AIR INTAKE

The outside air intake(s) shall be located to provide the cleanest possible source of fresh air for the building and shall be so placed, relative to the building's exhausts, vent stacks, etc., as to prevent entrainment of contaminated air from outside sources, including, but not limited to, fume hood exhaust, vehicle exhaust, exhaust from adjacent structures, and sources of potential microbial contamination, such as vegetation, organic matter, and bird and animal droppings.

15.9.7 VENTILATION RATES

Ventilation devices, in general, shall be those recommended in ASHRAE standard 62-1989 and Section 1 of *Indoor Air Quality Requirements: Design Process*. At a minimum, Table 15.9.7, Special Ventilation Rates, shall be taken into account in the design of the system.

Table 15.9.7 Special Ventilation Rates

Area	Ventilation Requirements
Laboratories	A minimum of 8 air changes per hour, single-pass air, per ASHRAE 62-1989 and this Manual, subsection 15.5.11.
Offices and administrative spaces	As required for human comfort but with a minimum of 20 cfm of outside air per occupant as stated in ASHRAE 62-1989.
Chemical storage	Must meet NFPA 30 or NFPA 45 requirements, depending on use. Minimum of 6 to 10 air changes per hour, single pass only.
Smoking rooms	Air supply from smoking rooms shall not be recirculated. Air should be exhausted to outside by separate ductwork and exhaust fan. Minimum of 60 cfm of outside air per person, per ASHRAE 62-1989.

15.9.8 ROOM AIR CHANGE RATES

EPA experience generally shows that the existing policy, which calls for a minimum of eight air changes per hour, provides sufficient dilution to manage background levels of toxic substances and is acceptable in terms of chemical analysis operations, odor control, comfort, and provision of 20 cfm of outside air per

person. Air change rates may have to be greater to provide heat control or to provide adequate ventilation for exhausting toxic or noxious materials.

15.9.9 PLUME STUDY (LABORATORY EXHAUST)

A study of prevailing wind patterns shall be obtained for the proposed building site. The study shall be performed to ensure proper design height of the laboratory exhaust stack(s) and of fresh-air intake locations. Stack design shall consider all elements of the site, including ground-level landscaping, large variations in terrain, complex groupings of adjacent buildings, height and massing of building(s) (taking into account exterior details), complex emission geometry, orientation to prevailing winds, nature of discharge particles, and volume of discharge. On the basis of the results of this study, the design professional can recommend optimum building orientation on the site and incorporate structural details that minimize effects on the dispersion of exhaust emissions.

15.10 Plumbing

15.10.1 PIPING

These criteria apply to plumbing systems (fixtures, supply, drain, waste and vent piping, service water heating system, safety devices, and appurtenances) inside the building and up to 5 feet beyond the building exterior wall. For new systems, domestic water shall be supplied by a separate service line and not by a combined fire protection and potable-water service or a combined process water and potable-water system within the building. Plumbing shall comply with the National Standard Plumbing Code (NSPC) (or another locally adopted, nationally recognized plumbing code), the ASHRAE handbooks, and ASHRAE standard 90.

15.10.1.1 SUPPLY

Type K copper tubing shall be used below grade. Type L copper tubing shall be used above grade. Chlorinated polyvinyl chloride (CPVC) and polybutylene (PB) plastic pipe and tubing may be used in lieu of copper tubing above grade where not subject to impact damage or otherwise prohibited by the project criteria.

- Fittings for Type K tubing shall be flared brass, solder-type bronze or wrought copper. Fittings for Type L tubing shall be solder-type bronze or wrought copper. Fittings for plastic pipe and tubing shall be solvent-cemented or shall use Schedule 80 threaded. No lead solder shall be used for copper pipe in potable-water systems.
- Stop valves shall be provided at each fixture. Accessible shutoff valves shall be provided at branches serving floors, fixture batteries for isolation, or at risers serving multiple floors. Shutoff valves also shall be provided to isolate equipment, valves, and appurtenances for ease of maintenance.
- Accessible drain valves shall be provided to drain the entire system. Manual air vents shall be provided at high points in the system.
- Provision for expansion shall be made where thermal expansion and contraction cause piping systems to move. This movement shall be accommodated by using the inherent flexibility of the piping system as laid out, by loops, by manufactured expansion joints, or by couplings.
- Accessible manufactured water hammer arresters shall be provided. Dielectric connections shall be made between ferrous and nonferrous metallic pipe.
- Where domestic water or fire protection service lines enter buildings, suitable flexibility shall be provided to protect against differential settlement or seismic activity, in accordance with the NSPC and NFPA 13, respectively.

15.10.1.2 DRAIN, WASTE, AND VENT LINES

Underground lines that do not service the laboratory areas shall be service-weight cast-iron soil pipe hub-type (with gasket); hubless cast-iron soil pipe may be used in locations where piping is accessible. Aboveground (above grade) lines that are 1½ inches in diameter and larger shall be either hubless or hub-type (with gasket) service-weight cast-iron pipe. Lines that are 1½ inches through 6 inches in diameter may be acrylonitrile-butadiene-styrene (ABS) or PVC plastic pipe where allowed by the project criteria. Pipe and fittings shall be joined by solvent cement or elastomeric seals. Lines that are less than 1½ inches in diameter shall be either (1) Type L copper with solder-type bronze fittings or wrought copper fittings or (2) galvanized steel with galvanized malleable iron recessed threaded and coupled fittings. Cast-iron soil pipe fittings and connections shall comply with Cast Iron Soil Pipe Institute (CISPI) guidelines. Provisions for expansion shall be included, as above. Underground lines servicing the laboratory area shall be acid-resistant sewer pipe ANSI/ASTM D-2146-69; polyethylene plastic pipe and fittings, Schedule 40, ASTM D-1785; poly (vinyl chloride) (PVC) plastic pipe, Schedule 40, 80, and 120, ASTM D-2241; poly (vinyl chloride) (PVC) plastic pipe (SDR-PR), ASTM D-2683; or socket-type polyethylene fittings for outside diameter-controlled polyethylene pipe. They shall be welded together following ANSI/American Welding Society (AWS) D1.1, structural welding code; ASTM D-2241; and ASTM D-2855. Solvent-cemented joints with poly (vinyl chloride) (PVC) pipe and fittings shall be made.

15.10.1.3 TRAP SEAL PROTECTION

A trap primer valve and floor/funnel drain with trap primer valve discharge connections shall be used where there is the possibility of loss of the seal in floor/funnel drain traps.

15.10.1.4 STERILIZATION

New supply systems or existing supply systems that have undergone rehabilitation will require sterilization in accordance with American Water Works Association (AWWA) C652, AWWA C5186, or the local governing plumbing code.

15.10.1.5 MISCELLANEOUS

Access panels shall be provided where maintenance or replacement of equipment, valves, or other devices is necessary. Escutcheons shall be provided at wall, ceiling, and floor penetrations of piping in occupied areas.

15.10.2 PLUMBING FIXTURES

Fixtures and appurtenances suitable for use by handicapped persons shall comply with the Americans with Disabilities Act (ADA). Fixtures shall contain no lead. Self-contained mechanically refrigerated coolers shall be provided wherever a need for drinking fountains exists. Ratings shall be based on ARI 1010. Electrical equipment shall be UL listed.

15.10.3 BACKFLOW PREVENTERS

Backflow preventers of the reduced-pressure-zone type shall be provided on any domestic water and fire protection lines serving the building. All domestic water lines shall be provided with water hammer suppressors and vacuum breakers at high points of supply lines or at the fixture.

15.10.4 SAFETY DEVICES

Tempering valves shall be of the fail-safe pressure-balance type. Hot-water generation equipment shall be provided with ASME code-stamped tanks, when of sufficient capacity, water temperature, or hot input rate to be within the jurisdiction of the ASME Boiler and Pressure Vessel Code. Approved pressure-relief devices—combination temperature-pressure or separate units, depending on the application—shall be provided. Backflow preventers and air gaps shall be used to prevent cross-connection (contamination) of potable-water supplies. Vacuum breakers (to prevent back-siphonage) shall be used only in conjunction with administrative controls.

15.10.4.1 PRESSURE-REDUCING VALVES

Pressure-reducing valves shall be provided where service pressure at fixtures or devices exceeds the normal operating range recommended by the manufacturer. Wherever a pressure-reducing valve's failure may cause equipment damage or unsafe conditions, a pressure-relief valve shall be provided downstream of the reducing valve.

15.10.5 EMERGENCY EYEWASH UNITS

Emergency eyewash units or combination eyewash/safety-shower units shall be provided in all work areas where, during routine operations or during foreseeable emergencies, the eyes of an individual may come into contact with a substance that can cause corrosion, severe irritation, or permanent tissue damage, or that is toxic by absorption. Eyewash units shall be designed to flush both eyes (double-headed unit) simultaneously and to provide hands-free operation. Units shall be placed in a location away from potential sources of hazard (e.g., fume hoods) and near the exit door. The eyewash units chosen should provide protection of the nozzle area with pop-off covers, and other protective features to prevent contamination of the flushing system. Design, operation, flow, water temperature, and similar characteristics shall meet the criteria in ANSI Z358.1-1990. Water for the units shall be supplied by the potable-water system. Eyewash units shall be in accessible locations that require no more than 10 seconds to reach; units should be no more than 50 feet travel distance from the potential hazard. Their location in all laboratory spaces shall be standardized as much as possible. The location shall be well lighted and shall be clearly identified with a highly visible sign. Final location shall be approved by the EPA project officer during the design phase.

15.10.6 EMERGENCY SAFETY SHOWERS

Emergency safety shower units shall be provided in areas where, during routine operations or during foreseeable emergencies, areas of the body may come into contact with a substance that is corrosive, severely irritating to the skin, or toxic by skin absorption. Each safety shower unit shall be equipped with an installed flexible hand-held drench hose with a spray head like that used in hand-held eyewash units; this shall be mounted on a rack. All piping for the emergency safety showers shall be above the ceiling except for the shower head and the pull bar connection. Design, operation, flow rates, and similar characteristics shall meet the criteria in ANSI Z358.1-1990. Water for shower units shall be supplied by the potable-water system. Rigid pull bars of stainless steel should be used to activate the shower and should extend to within 54 inches of the floor. The floor area of the emergency safety shower shall be textured, well lighted, identified with a highly visible sign, and maintained free of items that obstruct its use. A water flow alarm shall sound when the safety shower is activated. Location of safety showers shall be standardized as much as possible. Emergency safety showers in laboratories shall be located at the room entrance on the right-hand side of the exit door (hinge side); instrument laboratories and laboratory support spaces shall have showers located in the corridor at the pull side of the room door.

15.10.7 GLASSWARE WASHING SINKS

Sinks dedicated to the purpose of washing laboratory glassware shall have a high or telescoping spigot with a swing-type gooseneck to accommodate large pieces of glassware. Large sinks shall be provided with a hand-held sprayer whose weight is supported for ease of operation. All glassware washing sinks shall be ventilated at a rate of 280 to 300 cfm with an exhaust air duct connection at the top of the sink below the bench top.

15.10.8 COMPRESSED-AIR SYSTEMS

When compressed-air systems are required, these systems should have oil and water traps, a dryer, and all controls. Unless otherwise specified in the project criteria, each compressed-air system shall have duplex compressors (one redundant) with an automatic lead/lag switch and a single compressor tank. Compressed-air systems for processes shall be completely independent of the compressed-air system for the HVAC controls. The compressed-air system shall provide a water trap and pressure regulation at each laboratory. An audible alarm and remote annunciation shall be provided to alert personnel to a loss of air pressure. Air compressors shall use vibration pads and springs, as needed, to substantially diminish vibration and sound

generated by compressors. Further, compressor location should minimize transmission of vibration and sound to the building or rooms that the compressors service.

15.10.9 VACUUM SYSTEMS

When a laboratory vacuum system is required, it shall be composed of several vacuum pumps capable of evacuating air at a regulated suction of 25 inches of mercury or as specified in the project criteria. Storage volume and number of pumps shall be determined at the design stage as needed to meet laboratory benchwork requirements. Unless otherwise specified in the project criteria, each vacuum system shall have duplex pumps, an automatic lead/lag switch, and a single tank. An audible alarm and remote annunciation shall be provided to alert personnel to a loss of vacuum. Vacuum pumps shall use vibration pads and springs, as needed, to substantially diminish vibration and sound generated by the pumps. Further, pump location should minimize transmission of vibration and sound to the building or rooms that the pumps service.

15.10.10 CENTRALIZED LABORATORY WATER SYSTEMS

The following requirements apply to laboratory water systems.

15.10.10.1 DEIONIZED WATER (DI) SYSTEM

Unless otherwise specified in the project criteria, the central deionized water system shall have a resistivity of greater than 10 megaohms at the tap in each laboratory. Water quality shall conform to ASTM Type I requirements for reagent-quality water and to American Pharmaceutical Association (APhA) requirements for water used in microbiological testing. Type I water is typically prepared by distilling feed water that has a maximum conductivity of 20 megaohms per cm (at 25°C), then polishing it with mixed-bed deionizers and passing it through a 0.2-micron membrane filter. Pipes and fittings for the DI system shall be polyvinylidene fluoride (PVDF) schedule 80 or unpigmented polypropylene. A bypass or drain legs shall be provided at the lowest points in the piping system to avoid stagnation of water at the branch pipes during extended periods of non-use.

15.10.10.2 HOT AND COLD WATER, POTABLE

(Refer also to subsection 15.10.1.1.) The laboratory potable-water supply shall be piped in Type K or Type L copper. Only potable water shall be used for emergency eyewash units and emergency showers.

15.10.10.3 INDUSTRIAL HOT AND COLD WATER, NONPOTABLE

The laboratory nonpotable-water supply, identified as industrial hot/cold water, shall be piped in Type K or Type L copper. Approved backflow prevention devices shall isolate the laboratory nonpotable water system from the potable-water system. Hot-water supply shall be insulated, and hot water shall be recirculated to conserve energy.

15.10.10.4 CULTURE WATER SYSTEM

Culture water system piping shall be of Schedule 80 unpigmented polypropylene and shall have no metal in contact with the water. The holding tank shall be lined with unpigmented polypropylene. Transfer pumps shall be of solid unpigmented polypropylene.

15.10.11 NATURAL GAS DISTRIBUTION SYSTEM

Unless otherwise specified in the project criteria, each laboratory must have a natural gas distribution system.

15.10.12 NONFLAMMABLE- AND FLAMMABLE-GAS SYSTEMS

Systems for flammable and nonflammable gas must meet the following requirements.

15.10.12.1 GENERAL

Special gas services for flammable and nonflammable gases shall be provided to all laboratories requiring their use. Gases shall be stored and piped in accordance with NFPA 45, Chapter 8, and shall conform to Chapter 4, paragraphs 11 and 12, of the *Safety Manual*, as applicable.

- Gas cylinders for nonflammable gases, both in-use and standby, shall be manifolded from a remotely located space that is central to the laboratory areas and served by and accessible from the main storeroom or loading and receiving dock area. This space shall be designed and ventilated in accordance with code requirements.
- Flammable-gas cylinders shall be provided at the point of use only and shall be housed in ventilated cabinet enclosures with leak detection and alarm-monitoring devices.

15.10.12.2 DISTRIBUTION SYSTEMS

For all laboratories except metals analysis laboratories, a seamless-copper-piping gas-distribution system for nonflammable gases shall be provided from the space identified in the previous subsection to all designated laboratories. Ideally, the length of the gas distribution lines should not exceed 100 feet, to avoid the necessity for pipe joints. If pipe joints are required due to line length, prior approval by EPA is required. Each copper line of this system shall be placed inside a larger diameter PVC pipe and vented to the outside of the building. Regulator valves and other auxiliary equipment required to furnish gas at the required pressures shall be provided. Pipe sizes shall be coordinated to ensure proper velocity of the gas from the cylinders(s) to the point of application. The number and type of gas outlets in each room are indicated in the room data sheets. Exact and final outlet location in each laboratory must be approved by EPA during the design phase. The system design shall include a capability for individual room cutoff.

15.10.12.3 DISTRIBUTION TO METALS LABORATORIES

For all laboratories used for metals analysis, a seamless-Teflon-piping gas-distribution system shall be provided from the space identified in subsection 15.10.12.1. to all metals laboratories. The Teflon lines shall be placed inside larger PVC pipes and vented to the outside of the building. Each Teflon line in this system shall be equipped, at both ends, with regulator valves and other auxiliary equipment required to furnish gas at required pressures. Gas-distribution systems other than Teflon may be utilized if approved by EPA. Pipe sizes shall be coordinated to ensure proper velocity of the gas from the cylinder(s) to the point of use.

15.10.12.4 PIPING EXIT CORRIDOR RESTRICTION

No piping from any of these systems shall be run above or in the exit corridors.

15.10.12.5 BOTTLE GAS SUPPLY

The bottle gas supply shall be provided with duty and standby sets with automatic changeover valves and controls. For all gases, an indicator panel shall be installed close to the point of use in each of the laboratories. Rooms may be clustered in the panel as long as the distance between the point of use and the panel does not exceed 75 feet. See room data sheet requirements for the types, volumes, and other design information.

- Multipoint gas analyzer and alarm system. When toxic or explosive gases are used in a confined space, a multipoint gas analyzer and alarm system shall be provided to monitor concentration of the gases within this space. This system shall consist of gas sensors/transmitters, wiring, and a microprocessor-based monitoring-and-alarm control panel. The number and type of sensors/transmitters shall depend on the specific application. Each sensor/transmitter shall transmit a frequency signal proportional to the gas concentration and shall have a special amplifier to eliminate the effects of radio frequency interferences. The control panel shall be capable of monitoring, and providing an alarm on, different types of gases in different zones; the panel shall have an audible and

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a visible alarm. The control panel shall also have a factory-wired terminal strip to interface with the energy management system for remote monitoring and alarms.

15.10.12.6 LIQUID NITROGEN AND LIQUID ARGON

Liquid nitrogen and liquid argon must be delivered to the point of use in liquid form. Insulation in the delivery system must be sufficient to prevent evaporation losses of liquid nitrogen. The gas distribution room for these two gases shall be as close as possible to the laboratory rooms where the gases are used—preferably adjacent to them. This gas distribution room shall also be directly accessible from the outside of the building without use of the laboratory corridors. One large tank for each gas shall be provided; each tank shall be permanently fixed in the room. The tanks shall be outfitted with necessary valves and controls, as required by the gas supplier.

15.10.12.7 TESTING AND PURGING

Before acceptance, the distribution system must be pressure tested and purged. The required level of purity specified at the point of use shall be maintained at all points in the system during testing and purging.

15.10.13 DRINKING FOUNTAINS

At least one drinking fountain shall be provided on each block of space so that no person will have to travel more than 150 feet to reach it. The water shall be chilled. The refrigeration coils shall not be assembled using lead solder nor shall these coils contain lead as a lining. All drinking fountains and locations for drinking fountains shall comply with ADA.

15.10.14 TOILETS, SINKS, AND LAVATORIES

Requirements are as follows.

15.10.14.1 GENERAL

Separate toilet facilities for men and women shall be provided. The facilities must be located so that employees will not have to travel more than 150 feet to reach them. Unless otherwise specified by EPA, each toilet room shall have a sufficient number of water closets, with a minimum of two for each men's toilet room and a minimum of four for each women's toilet room, enclosed with modern stall partitions and doors. Each men's toilet room should also have at least two urinals. The number of water closets in each women's toilet room shall be no less than the sum of water closets plus urinals of the adjacent men's toilet room. The toilet rooms' hot water should be set at 105°F, or as required by the project criteria. Water closets and urinals shall not be visible when the toilet room entry door is open.

15.10.14.2 ACCESSORIES

Each main toilet room shall contain:

- A soap dispenser, shelf, and mirror above the lavatory.
- A toilet paper dispenser in each water closet stall.
- A coat hook on the inside face of each water closet stall door and on the wall immediately inside the door of the toilet room.
- At least one modern paper towel dispenser and waste receptacle for every two lavatories.
- A coin-operated sanitary napkin dispenser in women's toilet rooms.
- Ceramic tile or comparable wainscot from the floor to a minimum height of 4 feet 6 inches.
- A disposable-toilet-seat-cover dispenser.
- A convenience electrical outlet located adjacent to one mirror in each toilet room.
- A small covered container located inside each water closet partition enclosure in the women's toilet room for the disposal of used sanitary napkins.

15.10.14.3 TOILET ROOM ACCESSIBILITY

All public toilet rooms shall be located along an accessible path of travel; must have accessible fixtures, accessories, and doors and adequate maneuvering clearances; and shall meet UFAS and ADA requirements.

15.10.14.4 DIMENSIONS

All toilet rooms designated for public access shall have one toilet stall that:

- Is 60 inches wide.
- Has a minimum depth of 56 inches when wall-mounted toilets are used or 59 inches when floor-mounted sets are used.
- Has a clear floor area.
- Has a door that is 32 inches wide and swings out.
- Has handrails on each side (front-transfer stall) or on the side and back (side-transfer stall). Handrails shall be 33 to 36 inches high and parallel to the floor, shall be 1¼ to 1½ inches in outside diameter, shall have 1½ inches of clearance between rail and wall, and shall be fastened securely at ends and center. Handrails shall have no sharp edges and must permit the continuous sliding of hands.
- Has a water closet mounted at a height of 17 to 19 inches, measured from the floor to the top of the seat. Hand-operated or automatic flush controls shall be mounted no higher than 44 inches above the floor.

15.10.14.5 ALTERNATE DIMENSIONS

A toilet stall measuring 36 or 48 inches wide by 66 inches, but preferably 72 inches, deep may be acceptable, as determined by EPA.

15.10.14.6 LAVATORY ACCESSIBILITY

Accessibility shall be in compliance with ADA. At least one lavatory shall be mounted with a clearance of 29 inches from the floor to the top of the bottom of the apron. The height from the floor to the top of the lavatory rim shall not exceed 34 inches. Faucets shall be lever operated, push type, or electronically activated for one-hand operation without the need for tight pinching or grasping. Drain pipes and hot-water pipes under a lavatory must be covered, insulated, or recessed far enough so that individuals in wheelchairs who are without sensation will not burn themselves.

15.10.14.7 ACCESSIBLE MIRRORS, URINALS, AND ACCESSORIES

Accessibility shall be in compliance with ADA. One mirror with shelf shall be provided above the lavatory at as low a height as possible and no higher than 40 inches above the floor, measured from the top of the shelf and the bottom of the mirror. A common mirror provided for both the able and the disabled must provide a convenient view for both. Toilet rooms for men shall have wall-mounted urinals with elongated lips, with the basin opening no more than 17 inches above the floor. Accessible floor-mounted stall urinals with basins at the level of the floor are acceptable. The toilet room shall have at least one towel rack, towel dispenser, and other dispensers and disposal units mounted no higher than 48 inches from the floor, or 54 inches if a person in a wheelchair has to approach it from the side.

15.10.14.8 TOILET SCHEDULE

The number of water closets, urinals, and lavatories shall comply with all state and local codes and with project criteria. If a conflict exists between the project criteria and the state and local codes, the more stringent shall apply unless otherwise directed by the contracting officer.

15.10.14.9 WATER-CONSERVING WATER CLOSETS, SINKS, AND LAVATORIES

Flow control devices shall be installed (unless otherwise dictated by the project criteria) on all water closets, sinks, and lavatories. Devices shall limit water closet flow to 1½ gallons per flush, public lavatories to ½ gallon per minute, and regular lavatories to 1½ gallons per minute.

15.10.15 SHOWER STALLS

Shower stalls shall be of fiberglass construction, complete with door, soap ledge, shower head, separate hot- and cold-water knobs, non-skid floor finish, and standard 2-inch floor drain. Shower stalls shall also provide a small change area with lockers. Emergency shower deluge heads shall not be used in regular shower stalls. For more information about emergency showers see subsection 15.10.6. Accessibility shall be in compliance with ADA.

15.10.16 HOSE BIBBS

Three-quarter-inch hose bibbs should be provided on exterior walls of the building(s), 30 inches above grade. At least one hose bibb shall be installed on each wall. When an exterior wall exceeds 75 feet in length, additional bibbs shall be installed so that distance between bibbs does not exceed 75 feet. Depending on the geographical location of the facility, the design professional shall use freeze-proof hose bibbs.

15.11 Nonsanitary Laboratory Waste

All nonsanitary wastewaters from the laboratories are required to pass through an acid neutralization system prior to discharge into the local publicly owned treatment works. The system shall be designed and constructed in accordance with EPA standards for wastewater neutralization. The system shall have the capability of continuous pH flow monitoring and recording. The recorders shall be located in the office of the facility engineer, or in another suitable area. Sampling capability is required to allow for routine monitoring of facility wastewater effluent.

15.12 Codes and Standards

In addition to the references presented earlier in this section, the codes and standards of the organizations listed in Table 15.12, Codes and Standards, shall apply to all mechanical and plumbing systems, equipment, and piping, whether or not they are specifically listed in Section 15, Mechanical Requirements, of this Manual. In the event of conflict between the codes and standards of the listed organizations and other codes and standards that may be listed elsewhere in this document, the most stringent shall govern.

Table 15.12 Codes and Standards

AABC	Associated Air Balance Council
ACGIH	American Conference of Government Industrial Hygienists
ADC	Air Diffusion Council
AGA	American Gas Association
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
CGA	Compressed Gas Association
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSC	National Safety Code
NSF	National Sanitation Foundation
OIU	Owners Insurance Underwriters
OSHA	Occupational Safety and Health Act
SMACNA	Sheet Metal and Air-Conditioning Contractors National Association
UBCC	Uniform Building Code Congress
UL	Underwriters Laboratories

Other federal, state, and local authorities having jurisdiction.

15.13 Testing, Balancing, and Commissioning

15.13.1 INDEPENDENT CONTRACTOR

An independent air balance and testing agency that specializes in the balancing and testing of HVAC systems shall be used to balance, adjust, and test air-moving equipment and the air distribution system, water system, gas system, and compressed air-piping systems.

15.13.2 CONTRACTOR CREDENTIALS

The independent contractor shall be an organization (1) whose specialty is testing and balancing environmental systems, (2) that is a member of the Associated Air Balance Council (AABC) and the National Environmental Balancing Bureau (NEBB), and (3) that has satisfactorily balanced at least three systems whose type and size are comparable to those of this project.

15.13.3 CONTRACTOR REGISTRATION

The independent testing and balancing contractor shall be registered in the state in which the project is located.

15.13.4 SCOPE OF WORK

The testing and balancing work shall include, but shall not necessarily be limited to, the following items:

- All air-conditioning supply and return systems
- Air exhaust systems
- Hood supply and exhaust systems (including certification and performance testing)
- All hydronic systems
- Gas and compressed-air systems.

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15.13.5 TESTING AND BALANCING DEVICES

HVAC air and water distribution systems shall be provided with permanently installed calibrated testing and balancing devices and with access, as needed, to accurately measure and adjust water flows, pressures, or temperatures as required. At a minimum, the balancing devices in Table 15.13.5.1, Required Balancing Devices for Water and Steam Distribution Systems, and Table 15.13.5.2, Required Balancing Devices for Air Distribution Systems, shall be provided. Test devices shall be located and installed according to AABC Volume A-82.

Table 15.13.5.1 Required Balancing Devices for Water and Steam Distribution Systems

System Components (Water)	Required System Devices
Pump suction and discharge piping	Manifold pressure gauge with pressure taps
Pump discharge piping	Flow-measuring device (type depending on accuracy required) or inlet and discharge pressure gauges
Chiller evaporator water suction and discharge piping	Thermometer/test well; pressure gauge and gaugecock
Boiler or heat exchanger suction and discharge piping	Same devices as required for chiller evaporator piping
Heating or cooling coil (air-handling unit [AHU]) suction and discharge piping	Thermometer/test well; pressure gauge/pressure tap
Heating or cooling coil (AHU) discharge piping	Presetable calibrated balancing valve with integral pressure test ports
Reheat coil, fan coil unit, unit heater, ports, and finned tube radiation, convector: (1) discharge piping (2) suction piping	Presetable calibrated balancing valve with integral pressure test ports; temperature test; and pressure tap
Three-way control valves (each port) suction and discharge piping	Pressure tap
Boiler discharge piping	Flow-measuring device (orifice or venturi type)

Table 15.13.5.2 Required Balancing Devices for Air Distribution Systems

System Components	Required System Device
Diffusers, grilles, registers	Round butterfly or square/rectangular opposed-blade volume damper, either integral with device or in spin-in takeoffs
Branch ductwork runs	Rectangular/square or round (with more than one opposed-blade damper and terminal device). Sealed test hole for pitot tube traverse
Fan discharge ductwork	Sealed test holes for pitot tube traverse. Sealed test hole for static pressure measurements
Fan suction ductwork	Sealed test hole for static pressure measurement
Cooling coil suction and discharge airstreams	Duct-mounted airstream thermometer
Heating coil suction and discharge airstreams	Duct-mounted airstream thermometer
Mixed-air plenum airstream	Duct-mounted airstream thermometer

15.13.6 MECHANICAL SYSTEM COMMISSIONING

Before acceptance for occupancy and Government assumption of operating responsibilities for the facility, the lessor/contractor shall conduct commissioning of all mechanical and associated building systems. The lessor/contractor shall record all system operation verifications and submit a statement that all systems operations have been observed and that all systems meet the intent of the design and are operating properly.

15.13.7 REPORTING

The testing and balancing contractor approved by the contracting officer shall, at the completion of the balancing work, submit a complete report to EPA for approval. The report shall be delivered at least 15 days prior to final inspection of the building.

15.14 Ductwork**15.14.1 GENERAL**

The Contractor shall provide all ductwork, including that required for air supply and exhaust return of laboratory fume hoods and equipment. Ductwork systems shall be designed for efficient distribution of air to and from the conditioned spaces; noise, available space, maintenance, air quality, air quantity, and optimum balance between expenditure of fan energy (annual operating cost) and duct size (initial investment) shall also be considered.

15.14.2 FABRICATION

Ductwork for air supply, return air, and general exhaust shall be fabricated of galvanized sheet metal. Laboratory fume hood and equipment exhaust shall be of PVC-coated galvanized sheet metal or of Type 316 welded stainless steel, depending on the specific laboratory function and type of process being exhausted. Polypropylene and glass duct material shall be considered for highly corrosive exhaust applications. Construction of exhaust ductwork for laboratories with fume hoods shall conform to the requirements of ANSI/AIHA Z9.5-1992.

15.14.2.1 COMPLIANCE

Ductwork systems shall be designed to meet the leakage rate requirements of the SMACNA *HVAC Air Duct Leakage Test Manual*. Ductwork, accessories, and support systems shall be designed to comply with the following:

- ACGIH *Industrial Ventilation Manual*
- ASHRAE *Handbook of Fundamentals*
- NFPA 45 Fire Protection for Laboratories Using Chemicals
- NFPA 90A Installation of Air-Conditioning and Ventilating Systems
- NFPA 91 Installation of Exhaust Systems for Air Conveying of Materials
- NFPA 96 Ventilation Control and Fire Protection of Commercial Cooking Operations
- SMACNA HVAC Duct Construction Standards - Metal and Flexible
- SMACNA Fibrous Glass Duct Construction Standards
- SMACNA Round Industrial Duct Construction Standards
- SMACNA HVAC Duct Design Manual.

15.14.2.2 SPECIAL APPLICATIONS

Ductwork shall also meet the following requirements.

- Ductwork shall be designed to comply with NFPA 90A. This includes specifications and installation of smoke and fire dampers at rated wall penetrations and smoke pressurization/containment dampers as required for smoke pressurization/evacuation systems. Fire dampers shall not be used on the exhaust system ducting if the system must maintain confinement of hazardous materials during and after a fire.

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- Ductwork shall be designed to resist corrosive contaminants if any are present. Exhaust ductwork from laboratory fume hoods shall not be of spiral construction and shall be sloped toward the fume hood for drainage of condensation. Laboratory ductwork shall be in accordance with the requirements of NFPA 45.
- Ductwork that handles moisture-laden air that is exhausted from areas such as shower rooms, dishwashing areas, and other areas where condensation may occur on the duct interior shall be of aluminum construction, have welded joints and seams, and provide drainage at low points.
- Penetrations of ductwork through security barriers shall be minimized. Any such penetrations that are more than 96 square inches in area and 6 inches in smallest dimension must be provided with a penetration delay equal to that required for the security barrier. The physical attributes, intended service of the ductwork, and the axial configuration of the barrier penetration shall be considered in the design of the penetration delay.

15.14.3 ACCESS PANELS

All ductwork shall have an access panel that provides access to each operating part, including:

- Splitter dampers
- Manual volume dampers
- Motorized volume damper
- Fire dampers.

15.14.4 INSULATION

All supply air ductwork shall be insulated with a vapor barrier unless otherwise dictated by the project criteria. Supply air ductwork installed below ceilings and in conditioned spaces may not require insulation if the surrounding air has a low dew point and condensation will not occur. Return and exhaust air ductwork may be insulated where condensation may occur when air is routed through nonconditioned areas.

15.14.5 FIRE DAMPERS

Fire dampers shall be provided in accordance with codes, except in the exhaust systems of laboratory areas.

15.15 Fire Protection

15.15.1 GENERAL

The decision to install sprinkler protection in the facility shall be based on NFPA 101, NFPA 45, the *Safety Manual*, state and local codes, and the project criteria, whichever is most stringent. All sprinkler systems shall comply with NFPA 13 and be approved by Factory Mutual or another nationally recognized insurance company. Special protection systems may be used to extinguish or control fire in easily ignited, fast-burning substances such as flammable liquids, some gases, and some chemicals. Such protection systems shall also be used to protect ordinary combustibles in certain high-value occupancies that are especially susceptible to damage. Special protection systems supplement automatic sprinklers as described by NFPA and shall not be used as a substitute for them except where water is not available for sprinkler protection. Halon systems shall not be used unless directed by the project criteria.

15.15.2 WATER SUPPLIES

Except as noted below, every building shall be provided, at a minimum, with a water supply that is available for use by fire department mobile pumping apparatus. The water supply shall normally be provided by fire hydrants suitable for firefighting apparatus and located within 5 feet of paved roadways. The hydrants shall be supplied from a dependable public or private water main system. Alternative water supplies shall be developed in accordance with NFPA 1231. Other water supplies shall be available to buildings where fire protection requires them. Fire protection water does not have to meet drinking water standards.

The water supply system shall provide ample water for each of the three types of fire protection water use: outside fire department hose streams from hydrants, small and large hose streams from inside-building standpipe or hose connections, and automatic sprinkler systems. The minimum requirements for each type of water use shall not be cumulative or additive and are determined as described below.

15.15.2.1 FIRE DEPARTMENT HOSE STREAMS

The hose stream required shall be determined by using the needed fire flow calculation method outlined in Section 300 of the Fire Suppression Rating Schedule of the Insurance Service Office. The needed fire flow shall be based on the fire areas of the building, not on the entire area of the building. The fire flow for the fire area requiring the greatest water flow shall be the needed fire flow for the building.

15.15.2.2 STANDPIPE HOSE STREAM

When standpipe systems are provided or required, the minimum water supply shall be in accordance with NFPA 14 and the local building code and shall be based on the number of standpipe risers provided in the building or in each fire area.

15.15.2.3 AUTOMATIC SPRINKLERS

The minimum flow required to meet the needs of the automatic sprinkler system shall be determined by hydraulic calculations as required for sprinkler system designs. The water supply requirements shall include all sprinkler flow and required hose stream allowances outlined in NFPA 13.

15.15.3 SIZE AND ZONING

The sprinkler system main shall be sized to meet the fire flow and pressure requirements set by the local authority. Fire pump(s) shall be provided, if needed, and shall be installed in a separate room along with the sprinkler system main valves. Sprinkler system protection zones shall have the same boundaries as the fire alarm system fire zones. Each sprinkler system protection zone shall be equipped with electrically supervised control valves and water flow alarm switches connected to the fire alarm system.

15.15.4 SYSTEMS

Fire protection systems must meet the following requirements.

15.15.4.1 AUTOMATIC SPRINKLER PROTECTION

Automatic sprinkler protection shall be provided in all new EPA facilities. All sprinkler systems shall be hydraulically calculated in accordance with NFPA 13. All design documents, including the hydraulic calculations, must be maintained at the building to facilitate future modifications of the sprinkler system. Existing facilities shall be provided with sprinkler protection under the following circumstances:

- In major modifications to existing laboratories that use chemicals, flammable liquids, or explosive materials.
- Throughout all floors of any building where EPA occupancy is 75 feet high or higher. The height shall be measured from the lowest point of fire department access to the floor level of the highest occupiable story.
- Throughout occupancies exceeding the area or height limitations allowed by the local building code.
- In all areas below grade that meet the definition of “windowless” in local code.
- In all areas that contain a high-severity occupancy as defined by the General Services Administration (GSA).
- Throughout windowless buildings, windowless floors of buildings, and windowless areas that exceed the allowable limits of the local building code.

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- In cooling towers of combustible construction under the conditions described in subsection 15.5.5.
- In any location where the maximum fire potential of the occupancy exceeds the fire-resistance capabilities of exposed live-load-bearing structural elements (e.g., when a flammable-liquids operation is moved into a former office area).
- Throughout open-plan office space that has a fuel load in excess of 6 pounds per square foot.
- Throughout electronic equipment operation areas, including data storage areas. On/off type sprinkler heads and sprinkler guards may be used to minimize water damage in these areas.

15.15.4.2 WET PIPE

Sprinkler systems shall normally be wet pipe. Hydraulic designs shall be performed for all systems.

15.15.4.3 DRY PIPE

In unheated areas or other areas subject to freezing temperatures, dry-pipe systems shall be provided. Because of the time delays associated with the release of the air in the system, water demands for dry-pipe systems shall be computed on the basis of areas 30 percent greater than those used to computer demands for comparable wet-pipe systems. Where the unheated area is small, it may be cost-effective to install an antifreeze system or a small dry-pipe system supplied from the wet-pipe system in the main heated area.

15.15.4.4 PREACTION

A preaction system shall be used where it is particularly important to prevent the accidental discharge of water. Need for a preaction system shall be determined on the basis of review by, and recommendation of, a professional fire protection engineer. The detection system chosen to activate the preaction valve shall have a high reliability and shall be equipment with a separate alarm/supervisory signal to indicate status. The detection system must be designed to be more sensitive than the closed sprinklers in the preaction system but should not be so sensitive as to cause false alarms and unnecessary actuation of the preaction valve.

15.15.4.5 DELUGE

For extra hazard areas and specific hard-to-extinguish fuels such as explosives and pyrophoric metals, a deluge system with open sprinkler heads may be used to wet down the entire protected area simultaneously. Deluge systems shall comply with NFPA 13. If quick response is required, deluge system piping may be primed with water. The nozzles must be provided with blow-off caps for water-filled deluge systems.

15.15.4.6 SELF-RESTORING

Self-restoring sprinkler systems, such as the on/off multicycle system or systems using individual on/off sprinkler heads, shall be considered where the water from sprinklers will become contaminated by contact with room contents, where there is a concern about water damage, or where water supply or storage volume is marginal.

15.15.4.7 QUICK RESPONSE

Quick-response sprinklers must be used in new installations except where prohibited. Other specialized automatic sprinklers, such as large drop, early-suppression fast-response, or extended-coverage heads, are acceptable for use in sprinkler systems. The use of specialized sprinklers is appropriate when a higher level of protection is desired or an equivalent level of protection is necessary to compensate for failure to meet other code requirements. Use of specialized sprinkler heads should be limited to applications for which they have been specifically listed (e.g., UL, FM).

15.15.4.8 WATER SPRAY

Installation of water spray systems shall comply with NFPA 15.

15.15.4.9 CARBON DIOXIDE

Agent quantity requirements and installation procedures shall comply with NFPA 12.

15.15.4.10 DRY CHEMICAL

Systems shall comply with NFPA 17.

- Design requirements. Systems shall be designed in accordance with NFPA 17 and NFPA 96. Discharge of dry chemical shall actuate a pressure switch connected to an alarm in the building fire alarm system. Refer to Section 16, Electrical Requirements, of this Manual for fire alarm requirements.
- Acceptance tests. After installation, all mechanical and electrical equipment shall be tested to ensure correct operation and function. When all necessary corrections have been made, a full discharge test shall be conducted. Plastic or cotton bags shall be attached to each individual nozzle, and the system activated. Cooking appliance nozzles must discharge at least 2 pounds of the agent, and duct or plenum nozzles must discharge at least 5 pounds of the agent. Preengineered systems that fail to discharge these amounts will be considered unsatisfactory.

15.15.4.11 FOAM

Foam systems shall comply with NFPA 11, NFPA 11A, NFPA 16, NFPA 16A, and NFPA 409.

15.15.4.12 STANDPIPES AND HOSE SYSTEMS

NFPA 45 requires the installation of standpipe and hose systems in all laboratory buildings that are two or more stories above or below the grade level. Installation of standpipe systems shall comply with NFPA 14.

15.15.4.13 PORTABLE FIRE EXTINGUISHERS

Portable fire extinguishers shall comply with NFPA 10 except that halon extinguishers shall not be placed in any EPA facility. See Section 10, Specialties, of this Manual for more information on portable fire extinguishers.

15.15.4.14 HALON-1301 FIRE-EXTINGUISHING SYSTEMS

Fire protection systems that contain halon-1301 (CF_3Br , a halogenated hydrocarbon) shall not be used in EPA facilities. Existing systems that use halon-1301 should be removed from service in accordance with Title VI of the 1990 Clean Air Act Amendments. (The halon from the systems should have been recovered by the end of fiscal year 1994.) The hardware may be left in place in anticipation of an environmentally acceptable replacement. No new systems that use halon are to be installed in EPA facilities. This policy applies to both fixed and portable systems. The halon recovered from systems should be made available through the Halon Recycling Corporation (1-800-258-1283). Refer to list of acceptable halon substitutes approved under significant new alternatives policy (SNAP) as of October 16, 1996 (published by EPA's Air and Radiation Stratospheric Protection Division).

15.15.4.15 GASEOUS FIRE-EXTINGUISHING SYSTEMS

While carbon dioxide systems are allowed in normally occupied spaces, it is recommended that their use as a total flooding agent be limited to areas that are usually not occupied. Any carbon dioxide automatic extinguishing system that is to be used in usually occupied space must be reviewed and approved by AEREB and SHEMD and must meet the design requirements of NFPA 12 and 29 CFR §1910.162(b)5. A number of clean-agent, gaseous fire-extinguishing systems are becoming available as an alternative to halon and carbon dioxide systems. Among these are FM-200 and Inergen. Because of the unique nature and limited approvals for these new systems, any design and installation shall be certified by a

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licensed professional engineer as appropriate for the hazard to be protected against. The certification must include a detailed analysis of the hazards to be protected against; any limitations on, or exclusions of, hazardous chemicals that may be protected against by the design; and documentation to support the design concentration of the agent. Any documentation of the design shall meet the requirements under Flame Extinguishment of NFPA 2001. The installation of such a system shall meet the requirements described below.

- Design requirements. Systems shall be designed in accordance with NFPA 2001 and other applicable standards for the hazard to be protected against. Discharge of a system shall actuate a pressure switch or other device connected to initiate an alarm in the building fire alarm system. Refer to Section 16, Electrical Requirements, of this Manual for fire alarm requirements.
- Acceptance tests. After installation, all mechanical and electrical equipment shall be tested to ensure correct operation and function. All approval or acceptance testing shall be performed in accordance with Section 4-7 of NFPA 2001.

15.15.5 OPERATION

Operation and maintenance instructions and system layouts shall be posted at the control equipment. All personnel who may be expected to inspect, test, maintain, or operate fire protection apparatus shall be thoroughly trained and kept trained in the functions they are expected to perform.

15.15.6 CODES

In addition to meeting the code requirements mentioned in the above subsections, the design shall comply with the requirements of the local authority that has jurisdiction over the project.

END OF SECTION 15

Section 16 - Electrical Requirements

16.1 General

16.1.1 CODE COMPLIANCE

All work done in this section shall comply with the applicable requirements of the most current edition of the following codes and references:

- National Fire Protection Association (NFPA) codes and references
- National Electrical Code (NEC) (NFPA 70)
- Life Safety Code (NFPA 101)
- National Fire Alarm Code (NFPA 72)
- Installation of Air-Conditioning and Ventilating Systems (NFPA 90A)
- Factory Mutual (FM) Engineering Loss Prevention Data Sheet 5-4, Transformers
- Emergency and Standby Power Systems (NFPA 110)
- Stored Electrical Energy Emergency and Standby Power Systems (NFPA 111)
- Lightning Protection Systems (NFPA 780)
- 29 CFR §§1910.303-305
- *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, National Research Council
- Title III Standards for the Americans with Disabilities Act (ADA)
- Standards of the National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- Insulated Power Cable Engineers Association (IPCEA)
- Institute of Electrical and Electronics Engineers (IEEE) standards.

In addition, all work must comply with all applicable federal, state, city, and local codes, regulations, ordinances, publications, and manuals. All newly manufactured equipment shall be listed by Underwriters Laboratories Inc. (UL) or a similar testing laboratory acceptable to EPA. When codes conflict, the most stringent standard shall govern.

16.1.2 ELECTRICAL INSTALLATIONS

Electrical installations shall maintain the integrity of fire stopping, fire resistance, fire separation, smoke control, zoning, and other structurally oriented fire safety features in accordance with NEC Article 300-21 and NFPA 101.

16.1.3 ENERGY CONSERVATION IN DESIGN

After careful study of the facility's requirements as well as of the day-to-day operation of its various departments, the design professional shall design systems that meet facility operating requirements in an energy-efficient manner. The health and safety aspects of the operation must retain first priority, however, and cannot be relaxed or traded off for more efficient systems. System and lighting design shall comply with the requirements of American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) standard 90, the *Facilities Management and Services Division (FMSD) Energy Conservation Planning Handbook*, EPA's Green Lights Program and Partner Supports Program, and any state or local energy conservation codes or recommendations.

16.1.3.1 LOCAL ENERGY CONSERVATION PROGRAMS

The local utility company shall be contacted to investigate any energy conservation programs that they may have in effect. The economic validity of pursuing these programs shall be presented to EPA in the early design phase of the project, and if the programs are deemed viable, they shall be incorporated into the design for the project.

16.1.3.2 LOAD SHEDDING/PEAK SHAVING

The payback involved in introducing a load-shedding/peak-shaving system into the facility design shall be investigated. If the payback is sufficient to warrant the initial capital expenditure and if approval is obtained from EPA, this type of system shall be included in the design of the project. If a generator is involved in this system, careful consideration should be given to the rating of the generator and the type of duty it will be subject to. Such factors as the various fuel sources, exhaust fume contribution to outdoor air quality, local air quality standards, and energy-efficient generator equipment shall also be considered.

16.1.3.3 DEMAND-SIDE MANAGEMENT SYSTEM

A demand-side management system to keep the peak demand for the facility below a predetermined level shall be investigated. An economic analysis shall be done to determine the payback on such a system (if demand rates are already very low, this type of system may not be economically feasible).

16.1.4 COORDINATION OF WORK

A coordinated set of documents (i.e., coordination between architectural; electrical; heating, ventilation, and air-conditioning [HVAC]); plumbing; equipment; and structural systems for bidding) shall be provided. Documentation shall clearly identify the division of work among the trades and delineate the coordination responsibilities of the contractor. Special attention shall be given to designed-in equipment and equipment to be provided by the facility occupants.

16.1.4.1 CALCULATIONS

Short-circuit, load, and lighting calculations shall be provided early in the design phase.

16.1.5 POWER FACTORS

Electrical utilization equipment rated greater than 100 volts (V), as well as all lighting equipment, shall have a power factor of not less than 85 percent under rated-load conditions. If the equipment to be used for this project cannot be obtained with the above power factor, power factor correction devices shall be installed to bring the building system power factor up to 85 percent. All required devices shall be switched with the utilization equipment unless doing so results in an unsafe condition.

16.1.6 HANDICAPPED ACCESSIBILITY REQUIREMENTS

The facility shall also comply with the electrical requirements of the Uniform Federal Accessibility Standards (UFAS) (1984), adopted by the General Services Administration (GSA) in 41 CFR Parts 101-19.6, as well as with ADA and all state and local laws and standards for buildings and facilities that must be accessible and usable by physically handicapped people. The most stringent of these codes shall apply.

16.1.7 MATERIAL AND EQUIPMENT STANDARDS

All specified materials and equipment shall be standard products of manufacturers that are regularly and currently engaged in production of such items. Items that are obsolete or to be discontinued by the manufacturer, as well as materials and equipment of an experimental nature (or products that would be installed in a facility for the first time with this project), are not acceptable and will not be permitted. All material and equipment shall be specification grade, new, free from defects, and high quality, and shall be entirely suitable for these specific facilities.

16.1.8 ENVIRONMENTAL REQUIREMENTS

Careful consideration shall be given in the design to the types of materials to be used for the project as they relate to the environment in which they will be installed. Exterior equipment may be subject to different types of corrosive atmospheres. Interior equipment in laboratories and testing and storage areas may also be subject to corrosive conditions. All equipment and material shall be suitable for the environment in which it will be installed. Noise mitigation shall be provided for equipment such as transformers and generators.

16.2 Primary Distribution

16.2.1 DUCTBANKS AND CABLE

All primary cable shall be run underground in ductbanks for new building sites. For extension of, or addition to, existing buildings where primary cabling will be used to extend an existing system to a new substation, primary cabling may be run within the building provided that it is installed in a raceway system (conduit) appropriate to the installation.

16.2.1.1 DUCTBANK ENCASEMENT

All underground ductbanks shall be concrete encased for primary circuits (600 volts and above) and where secondary-service reliability is a prime consideration. Minimum duct size shall be 2 inches. A minimum of 25 percent spare ducts (but not less than two spare ducts) shall be provided in each duct run. Spare ducts shall be plugged or capped to prevent contamination. The locations where manholes are to be included shall be investigated to ensure that they will drain properly. Ductbank runs shall be located in the exterior utility corridors established in the master plans. Locations shall be carefully coordinated with other site utilities in the corridor to avoid any conflicts. A 4-inch-wide yellow plastic marker tape saying "Danger: Buried High Voltage Cable" shall be placed directly over the high voltage line at no more than 6 inches below finished grade.

16.2.2 SWITCHES

When a new campus-type utility distribution system or an extension of an existing campus-type distribution system is a part of the project, a loop system shall be considered. This system shall have sectionalizing primary switches. Primary switches shall be of load break design. All switches shall be pad mounted. Enclosures for switches shall be suitable to the environment in which the switches will be located. Where switches are to be located indoors, they shall be physically isolated from any emergency electrical equipment and shall be located in electrical rooms only.

16.2.3 OVERHEAD POWER SUPPLY LINES

Overhead power supply lines can be used only where service is to be installed in remote or unsettled areas, industrial areas, or areas where underground service is not feasible. Maximum use shall be made of single-pole structures. Overhead power supply lines may also be used for feeders to small single-phase loads or buildings. Careful consideration shall be given to the location of overhead lines in relation to future land use.

16.2.3.1 POWER AND COMMUNICATION POLES

Joint use of poles for power and communications distribution shall maintain safety standards and shall limit electrical interference to communications services. In joint use of poles, either for multiple electrical distribution systems or for both electrical distribution and communication lines, underbuilt lines or cables shall be of vertical construction. Use of double-stacked cross run construction shall be allowed only where proper clearances for hot-line maintenance work can be ensured. Clearances shall comply with American National Standards Institute (ANSI) standard C2.

16.2.4 SYSTEM REDUNDANCY

A risk/benefit analysis should be performed to justify added capital costs for system redundancy.

16.3 Service Entrance

16.3.1 OVERHEAD SERVICES

Overhead services to buildings should not be used except in particular circumstances where underground services are not feasible, and then only with approval of the EPA contracting officer's representative (COR). Where electrical service to the building is by overhead lines, proper dip poles, weatherheads, and supports shall be provided. The main service switch, panelboard, or switchboard shall be located immediately adjacent to the entrance of feeders into the building. Code-required clearances shall be maintained under all overhead lines. The openings necessary for bringing conductors into buildings shall be grouted or otherwise fire-stopped.

16.3.2 UNDERGROUND SERVICES

To the greatest extent possible, public utility transformers shall be located outside of the actual building. If public utility transformers must be located within buildings because of site constraints, they shall be installed in standard transformer vaults conforming to the requirements of the NEC. These vaults shall not be located adjacent to, or directly beneath, any exit from the building.

16.3.3 SERVICE CAPACITY

Incoming transformers must be provided, as required, and must be of sufficient capacity to accommodate the full design load. In calculating the design load, a demand factor of 100 percent should be used for lighting and fixed mechanical equipment loads and a demand factor of 75 percent for all other loads. The incoming service shall have sufficient capacity to accommodate the full design load plus 30 percent additional capacity for future growth.

16.3.4 METERING

Where medium voltage power is brought to the facility, electrical energy metering (kilowatt hour [kwh]) shall be furnished at each substation of 500 kilovolt-ampere (kVa) or greater capacity. Demand metering (kilowatt demand [kwd]) shall be furnished as required for load management. The economics of primary metering and secondary metering for campus-type facilities shall also be investigated; the most cost-effective method shall be used.

16.3.4.1 LOCAL UTILITY COMPANY

Coordination with the local utility company should be performed to determine points of utility metering requirements. Single metering is preferred.

16.3.5 SERVICE ENTRANCE EQUIPMENT

Service entrance equipment shall consist of a main switch or switches, a main circuit breaker or circuit breakers, or a main switchboard or panelboard. In determining whether the service entrance equipment should be of the fused or circuit breaker type, careful consideration shall be given to the short-circuit current available at various points in the proposed distribution system.

16.3.5.1 SPECIFIC REQUIREMENTS

All service entrance equipment shall have copper busing. If the main service consists of a switchboard or panelboard, it shall have at least 10 percent of the switchboard rating as spare breaker or switches and 20 percent of the rating as bused spaces. The electrical system shall be properly coordinated for selective tripping in order to permit removal of only that portion of the system that has experienced a fault or overload condition.

16.3.5.2 RENOVATION

If this project is a renovation or an extension of an existing building, the history of the loads shall be carefully studied to ensure that the existing service entrance equipment has sufficient capacity to handle the loads of the addition or renovation and has spare capacity for future loads.

16.4 Interior Electrical Systems

16.4.1 BASIC MATERIALS AND METHODS

Electrical systems shall be designed so that all components operate within their capacities for initial and projected loads. Preferred standard voltages (per ANSI C84.1) shall be used, with a single voltage level characteristic in any classification, in order to minimize stocks of spare equipment and to standardize operating and maintenance practices and procedures. On-site acceptance testing shall be required for each major electrical system. Tests shall be performed in the presence of EPA personnel. Copies of all test results shall be submitted for approval. All receptacles, switches, and wiring devices shall be specification grade. All safety switches shall be heavy duty. All equipment shall be new. Refer to subsection 16.13, Service Entrance, for requirements for electrical components located in various environmental conditions.

16.4.2 SERVICE EQUIPMENT

All service entrance equipment shall be UL listed for use as service entrance equipment. All components shall be factory wired for switchboards, panelboards, or unit substations before shipment. Service entrance equipment shall be physically isolated from all emergency power systems so that a failure in either system will not affect the operation of the other system. All service switchboards shall have factory-installed ammeters and voltmeters.

16.4.3 CONDUCTORS

All conductors (wire and cable) shall be copper. All conductors for systems operating at 480 volts and below shall have 600-volt insulation with distinctive markings, as required by UL, for identification in the field. All conductors shall be continuous, without splices. All conductors operating at 600 volts and above shall be insulated and shall have the appropriate voltage and insulation ratings as required by their location in the system and in the facility. Branch circuit wiring shall not be smaller than No. 12 American Wire Gage (AWG.) All conductors shall be color coded to identify each phase and the neutral. The grounding conductor shall be green or bare.

16.4.4 RACEWAYS

All electrical wiring shall be installed in conduit or raceway or shall be otherwise physically protected in accordance with the NEC. Conduit shall be at least $\frac{3}{4}$ inch. Conduits installed in stud partitions or above lay-in ceilings may be electrical metallic tubing (EMT). Conduit concealed in floor slab or in concrete masonry walls, or conduit run exposed 5.0 feet above finished floor, shall be of rigid galvanized steel. Polyvinyl chloride (PVC) conduit may be used underground to feed site lighting and site power circuits; the remaining outdoor conduits shall be of PVC-coated rigid galvanized steel.

16.4.4.1 CONDUIT

Service entrance conduits shall be concrete-encased PVC or PVC-coated rigid galvanized steel. Rigid galvanized steel conduit shall be used in hazardous areas, as described by the NEC, unless the environment is corrosive to steel conduit, in which case PVC conduit may be used. Aluminum conduit shall be used for high-frequency circuits, where steel will cause magnetic problems, or in atmospheres in which steel conduit is unsuitable. Aluminum conduit shall not be used underground, encased in concrete, or used in atmospheres that are corrosive to aluminum.

16.4.4.2 FLEXIBLE-METAL CONDUIT

Liquid-tight flexible-metal conduit shall be used for connections to meters, transformers, pumps, and other equipment, as required by the NEC, where vibration or movement can be a problem and where there is a need for protection from liquids, vapors, or solids.

16.4.4.3 RATED ASSEMBLIES

Raceways that penetrate fire-rated assemblies shall be noncombustible. Openings shall be sealed to maintain the established fire ratings as defined by UL.

16.4.4.4 SURFACE METAL RACEWAYS

Surface metal raceways shall be used to provide receptacles with power and for low-potential services (e.g., data, telecommunications, wiring) in the laboratories themselves. The design professional shall review and make recommendations to EPA concerning the type of surface metal raceways appropriate to the project. The design professional shall consider using single-compartment surface metal raceways (2 inches high by 1¾ inches deep, minimum size) where only power receptacles are required and double-compartment surface metal raceways (4¾ inches high by 2¼ inches deep, minimum size) where both power receptacles and telecommunications/data outlets are required. Raceway covers shall be precut to 12-inch sections. The raceway shall be divisible into two or three separate wiring components to facilitate installation of power or low-potential wiring. The material and color of the raceway shall be appropriate to the atmosphere in which the raceway will be installed.

16.4.4.5 PLENUMS, DUCTS, AND OTHER AIR-HANDLING SPACES

All wiring shall be in accordance with NEC Article 300, except that communication circuits (Article 800) and Class 2 and Class 3 circuits (Article 725) need not be run in conduit when conductors are of materials that are classified by UL as having adequate fire-resistant and low smoke-producing characteristics.

16.4.5 HARMONICS

The design of the electrical distribution system (both normal and emergency power) shall take into account the effects that harmonics from nonlinear loads can produce on the system. Harmonics from nonlinear loads can affect the capacities of the neutral conductor, panelboards, phase conductors, and emergency generators. “K” rated transformers shall be used where the associated panelboards are feeding a large quantity of nonlinear loads. Special attention shall be given to the harmonics produced by variable-speed and variable-frequency drive units used for control of HVAC equipment.

16.4.5.1 NEUTRAL CONDUCTOR

The neutral conductors of four-wire system feeder(s), directly serving nonlinear load shall be sized at double the amperes of the phase conductors through the entire interior electrical distribution system. The neutral conductors of 480/272-volt, four-wire feeders serving the lighting panels that control the electronic ballast fluorescent fixtures shall be sized at double the wire size of the phase conductors.

16.4.6 DISTRIBUTION EQUIPMENT

The facility may have special requirements with respect to ground fault protection on the main switchboard (such as two levels of ground fault). EPA shall be consulted concerning any special requirements above those required by the NEC. Ground fault protection shall be used in all laboratory areas where personnel are operating electrical equipment and are exposed to electrical shock hazards while operating the equipment. Ground fault protection systems shall also be installed in areas where they are required by the *Safety Manual*.

16.4.6.1 TRANSFORMERS

Transformers shall be located and installed in accordance with NEC Article 450 and in such a way as to minimize the fire and contamination hazards to the EPA facility and its occupants. The following requirements also apply:

- Whenever any public utility transformer or other equipment involves a dielectric fluid that is combustible, toxic, or otherwise hazardous, it shall not be located inside an EPA facility.
- Utility transformer vaults or transformer locations abutting an EPA building shall conform to the requirements of the NEC. Transformer equipment shall not be located adjacent to, or directly beneath, any exit.

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- Transformers, fluorescent fixtures, and other electrical devices containing polychlorinated biphenyls (PCBs) shall not be used in EPA facilities.
- All transformers located within an EPA building shall be dry-type only, unless they are located within a transformer vault.

16.4.6.2 DRY-TYPE TRANSFORMERS

Dry-type transformers shall be provided with four 2.5 percent taps, two above and two below rated primary voltage. All transformers shall be designed for continuous operation at not more than a 150 degrees Celsius (°C) temperature rise, above 40°C ambient. All transformers shall conform to the design, temperature-rise, testing, and other requirements specified by the Acoustical Society of America (ASA), NEMA, and IEEE standards and shall have a rated sound level of 45 decibels (dB) or below. To ensure against objectionable levels of noise being transmitted through the building, the dry-type transformers shall be mounted on approved vibration-eliminating mountings. Connection to transformers shall be made with flexible steel conduit (Greenfield) with grounding jumper. All transformers shall comply with the requirements of the *Safety Manual*. All dry-type transformers shall be designed for nonlinear loads and shall be isolated-type transformers. They shall not be K-rated and shall be shielded and located as close as possible to the load. The designer shall consider the use of shielded isolation transformers or uninterruptible power supply (UPS) power for sensitive computer and other electronic equipment loads.

16.4.6.3 OUTSIDE SUBSTATIONS AND TRANSFORMER INSTALLATIONS

In addition to the requirements above, outside substations and transformers shall meet the following requirements:

- The installation of transformers should meet the most current requirements of Article 450 of the NEC.
- Transformers insulated with a dielectric fluid identified as nonflammable shall be permitted to be installed indoors or outdoors. If such transformers are installed indoors, they shall be within a transformer vault and furnished with a liquid confinement area and a pressure relief vent. A nonflammable dielectric fluid is one that does not have a flash point or fire point and is not flammable in air.

16.4.6.4 PANELBOARDS AND CIRCUIT BREAKERS

Panelboards and circuit breakers must meet the following requirements.

16.4.6.4.1 COMPLIANCE

Panelboards shall comply with UL 67 and UL 50. Panelboards for use as service-disconnecting means shall also conform to UL 869. Panelboards shall be equipped with a circuit breaker. Design shall be such that any individual breaker can be removed without disturbing adjacent units and without loosening or removing supplemental insulation supplied as a means of obtaining clearances as required by UL. Where "space only" is indicated, provisions should be made for the future installation of a breaker, which shall be sized as indicated. All panelboard locks included in the project shall be keyed alike. All distribution panels serving fluorescent fixtures, laboratory room distribution panels, and any other panels serving nonlinear load shall be UL listed and labeled for nonlinear loads.

16.4.6.4.2 DIRECTORIES

Directories shall be provided to indicate the load served by each circuit. These directories shall be typed and shall be mounted in a holder behind transparent protective covering. Bus board shall be supported on bases independent of the circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. An isolated neutral bus

shall be provided in each panel for connection of circuit-neutral conductors. A separate ground bus marked with a yellow stripe along its front and bonded to the steel cabinet shall be provided for connecting grounding conductors. A separate ground bus marked with a green strip along its front and isolated from the panel cabinet shall be provided for connecting isolated insulated ground wires.

16.4.6.4.3 CIRCUIT BREAKERS

Circuit breakers shall comply with Federal Specification W-C 375 and shall be thermal magnetic type with an interrupting capacity of 10,000 amperes symmetrical minimum. Breaker terminals shall be UL listed as suitable for the type of conductor provided. Plug-in circuit breakers are not acceptable. Common trip-type multiple breakers with a single operating handle shall be provided. Breaker design shall be such that an overload in one pole automatically causes all poles to open. Phase sequences should be maintained throughout each panel so that any adjacent breaker poles are connected to phases A, B, and C, respectively. Circuit breakers should be provided with ground fault interrupter (UL 1053 and the NEC). In addition, circuit breakers should be provided with a push-to-test button, visible indication of tripped condition, and an ability to detect a current imbalance of approximately 5 milliamperes.

16.4.6.4.4 SHUNT TRIP BREAKERS

Shunt trip breakers shall be provided in branch circuit panelboards, as designated by EPA, to remove power to laboratory modules or other areas or equipment upon activation of fire protection systems or devices in the immediate area.

16.4.6.5 LABORATORY MODULE

Each laboratory module shall be provided with a separate 120/208-volt, three-phase, four-wire panelboard. The branch circuit system shall be as flexible as possible to accommodate any type of laboratory alteration. In addition, each laboratory module shall be provided with emergency power from an emergency power panelboard; the emergency power panelboard may serve more than one module. The panelboard should be rated for nonlinear loads.

16.4.6.6 WIRE CLOSETS

Wire closets that leave passages between floors constitute shafts and shall be protected in accordance with local building codes and the *Safety Manual*. In any case where wire closet ventilation arrangements or other features cannot conform to the requirements for a shaft, all openings through the floor shall be fire-stopped (grouted). In any building where smoke control systems are likely to be involved, such additional fire stopping, or other methods to increase the smoke passage resistance of openings around doors or through wire passes, shall be provided as necessary to meet the needed level of efficiency for smoke control systems.

16.4.7 MOTOR CONTROLLERS AND DISCONNECTS

Motor controllers and starters shall be provided for all motors and equipment containing motors. All controllers shall have thermal-overload protection in each phase. Magnetic-type motor controllers shall have undervoltage protection when used with momentary-contact pushbutton stations or switches and shall have undervoltage release when used with maintained-contact pushbutton stations or switches.

When used with a pressure, float, or similar automatic-type or maintained-contact switch, the controller shall have a hand-off-automatic selector switch. Connections to the selector switch shall be such that only the normal automatic regulatory-control devices will be bypassed when the switch is in the "hand" position. All safety control devices, such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor circuit in both the "hand" and the "automatic" positions. Control circuit connections to any hand-off-automatic selector switch or to more than one automatic regulatory-control device shall be made in accordance with a manufacturer-approved wiring diagram. The selector switch shall be capable of locking in any position.

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For each motor that is not in sight of the controller, either the controlled disconnecting means shall be capable of being locked in the open position or a manually operated, nonfused switch that will disconnect the motor from the source of supply shall be placed within sight of the motor location.

Overload protective devices shall give adequate protection to the motor windings, shall be of the thermal inverse-time-limit type, and shall include a manual-reset pushbutton on the outside of the motor controller case. The cover of a combination motor controller and manual switch or circuit breaker shall be interlocked with the operating handle of the switch or circuit breaker so that the cover cannot be opened unless the handle of the switch or circuit breaker is in the off position. Variable-frequency drive units shall be considered for larger HVAC equipment loads, and for other motor loads as feasible. See Section 15, Mechanical Requirements, of this Manual for equipment to be used with variable-speed drives.

16.4.7.1 CONTROL EQUIPMENT

Control equipment shall comply with the National Electrical Manufacturers Association (NEMA) Industrial Controls and Systems (ICS) standards and with UL 508. Single-phase motors may be controlled directly by automatic control devices of adequate rating. Automatically controlled polyphase motors and all polyphase motors rated greater than 1 horsepower (hp) shall have magnetic starters. Control devices shall be of adequate voltage and shall have an adequate current rating for the duty to be performed. Pilot control circuits shall operate with one side grounded and at no greater than 120 volts. Where control power transformers are required, they shall be located inside the associated motor starter housing, shall be protected against faults and overload by properly sized overcurrent devices, and shall be of sufficient capacity to serve all devices connected to them without overload. Reduced-voltage starters shall be provided for larger motors to avoid an unacceptable voltage dip when the motors are started.

16.4.7.2 SAFETY DISCONNECT SWITCHES

Safety disconnect switches shall be provided for all hard-wired electrically operated equipment and motors in locations where they are required by code. Switches shall meet the requirements of Federal Specification W-S 865c and NEMA Type HD. Enclosure shall be NEMA I for indoor use and NEMA 3R for exterior use. All safety switches shall be horsepower rated. The switches shall be of the quick-make quick-break type, and all parts shall be mounted on insulating base to permit replacement of any part from the front of the switch. All current-carrying parts shall be of higher rated load without excessive heating. Contacts shall be plated to prevent corrosion and oxidation and to ensure suitable conductivity.

16.4.7.2.1 GROUND FAULT PROTECTION OF EQUIPMENT

With the exception of emergency systems, systems carrying 150 volts or greater to ground and not exceeding 600 volts phase-to-phase shall be provided with ground fault protection for each service-disconnecting means rated 1,000 amperes or more. Necessary precautions shall, however, be taken to minimize the possibility of nuisance tripping. In addition, all buses or other conductors at motor control centers, switchgear, switchboards, and busways shall be insulated or isolated.

16.4.7.2.2 GROUND FAULT CIRCUIT INTERRUPTER PROTECTION FOR PERSONNEL

At a minimum, ground fault circuit interrupter (GFCI) protection shall be provided for all 125-volt, single-phase, 15- and 20-ampere receptacles located outdoors; elevator electrical systems; as required by NEC Article 620 and the National Research Council's *Prudent Practices*; and receptacles installed on roofs. GFCI protection shall also be required in the following circumstances:

- In any location where EPA personnel are operating electrical equipment in direct contact with water or other liquids or where electrical receptacles are installed within 6 feet of a sink provided with a plumbed water supply or a drain, tub, or other water source.
- If GFCI protection is prescribed for electrical equipment by the equipment's manufacturer.

- If previous experience indicates a need for GFCI protection.

This protection shall be provided in new and existing construction by means of interrupter devices incorporated in receptacles or circuit breakers. These GFCI receptacles may be terminating type or feed-through type, whichever will satisfy the need. GFCI receptacles shall be color coded or shall otherwise indicate GFCI protection. Scheduled testing of the GFCI is required in accordance with the manufacturer's recommendations, but not less than semiannually.

16.4.7.2.3 REMOVAL OF GFCI CIRCUITS

Existing circuits with GFCI protection shall remain unless persistent problems are encountered or unless renovations occur that would alter the use so that GFCI protection is not necessary. An example of such a renovation would be converting an aquatic laboratory to office space. Upon completion of the initial installation, the electrical ground system shall be checked or verified for continuity with the conduit system, the equipment housing, and the final connection to the receptacle grounding stud. In aquatic laboratories and other required areas, not only will the GFCI-protective device be installed in the receptacle, but also the receptacles will be connected to the grounded system.

16.4.7.3 MOTOR CONTROL CENTER

Where several motors (all of larger-than-fractional horsepower) are located in one room or space, a motor control center should be used. Busing in the control center should be arranged so that the center can be expanded from both ends. Bus shall be of silver-plated copper. Interconnecting wires shall be copper. Terminal blocks should be of the plug-in type so that controllers may be removed without disconnecting individual control wiring.

16.4.8 GROUNDING

The grounding system for the facility shall be permanent, effective, and complete from the service entrance to most electrical devices. The grounding system shall conform to the mandatory and applicable advisory rules of NEC Article 250. In addition, green insulated copper ground wire shall be connected between each laboratory electrical outlet and the feeder panel isolated ground bus. This conductor shall be sized in accordance with NEC Table 250-95. Grounding systems shall comply with the NEC and IEEE 142. A separate ground conductor shall be used. Raceway systems shall not be used as a ground path.

16.4.8.1 LABORATORY BUILDING MODULE GROUNDING

In addition to the grounding indicated above, all laboratory building modules shall have a bare earth copper ground grid or field, direct buried outside, to provide an isolated ground for instrumentation. This ground system (and any other isolated ground system required for special areas) shall be clearly identified and protected against improper usage. All building ground systems shall be tied together as required by NEC Article 250.

16.4.8.2 GROUND BUS

Every panelboard and switchboard in the facility shall be provided with a ground bus.

16.4.9 LABORATORY POWER REQUIREMENTS

See the room data sheets for specific and generic laboratory room requirements. Specific and generic electrical requirements are indicated for most spaces. In the design of a new facility, however, these requirements must be reviewed, verified, and tested with the appropriate EPA representatives and must gain approval from EPA. This reviewing, verification, and testing should occur during the program verification and design phase of the project. Refer to subsections 16.4.6.4 and 16.4.8.1 above for requirements for panelboard and grounding requirements for laboratory modules, respectively. In addition, the following requirements apply:

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- All 120-volt general convenience receptacles shall be rated a minimum of 20 amperes and shall be grounding type (NEMA 5-20R) and specification grade.
- 120-volt circuits shall have a minimum rating of 20 amperes.
- A maximum of four general convenience receptacles shall be connected to a circuit.
- Equipment such as refrigerators, freezers, and centrifuges shall each have individual dedicated circuits.
- Receptacles for 6-foot-long or longer fume hoods shall be alternately wired for two circuits.
- Receptacles located within 6 feet of a sink shall be GFCI type.
- All branch circuits or panelboard feeder conduit runs shall be provided with separate equipment grounding conductors sized per NEC Table 250-95.
- Each laboratory shall be provided with separate, dedicated 120/208-volt, three-phase, four-wire panelboards; panelboards shall be spaced at a maximum spacing of one panelboard every two modules. Additional panelboards shall be provided as required by electrical usage or as directed by the EPA project officer.
- Each laboratory panelboard shall be provided with a separate ground bus.
- Receptacles that are located above wall or island benches and at equipment spaces shall be in surface metal raceways wherever possible. Raceways shall be single compartment or double compartment (for both power and telecommunications/data) as directed by the EPA project officer.
- In accordance with NEMA 14-30R, 30-ampere, 125/250-volt single-phase receptacles will be provided for 30-ampere, 208-volt single-phase equipment.
- One receptacle on a dedicated 20-ampere, 120-volt emergency power circuit shall be provided in each laboratory. Emergency power shall also be provided for special equipment requiring such power.
- UPS systems within the computer/data-processing rooms and laboratories and their supply and output circuits shall comply with NEC Article 645-10.

16.5 Interior Lighting System

16.5.1 ILLUMINATION LEVELS

The minimum acceptable levels of maintained illumination shall be as indicated in Table 16.5.1, Illumination Levels, for the particular areas. For areas not listed in Table 16.5.1, the recommendations of the Institute of Environmental Science (IES) handbooks shall be followed.

Table 16.5.1 Illumination Levels

FUNCTION	FOOTCANDLES	FUNCTION	FOOTCANDLES
General office space	50	Stairways	20
Animal room	70	Storage	
Autopsy	100	Inactive	5
Boiler room	20	Rough bulky	10
Corridors	25	Medium	20
Emergency lighting (general)	3	Fine	50
Emergency lighting in laboratory blocks	5	Telephone equipment room	70
Examination	100	Toilets	30
Laboratories (dual switching)	50/100	Exterior entrances	5
Loading dock	20	Desk level (task lighting)	70-100
Lobby	50	Utility rooms	20
Locker rooms	20	X-ray	10
Shops (dual switching)	50/100	Parking decks	5
General office and record rooms	50	Library-conference rooms (dual switching)	50/100
Parking, driveway, and walkways	1-3		

Note: These values represent general illumination 30 inches above the floor.

16.5.2 LIGHTING CONTROLS

Switches shall be provided to control lighting in all areas. Large rooms (more than 200 square feet) shall have multiple switching to reduce the lighting level by approximately half.

16.5.2.1 DAYLIGHT-LEVEL SENSORY CONTROLS

In building areas (except laboratories) that are larger than 200 square feet and that will have a large contribution of natural daylight, daylight-level sensory controls shall be used to control lighting levels.

16.5.2.2 BUILDING AUTOMATION SYSTEMS

In buildings with building automation systems (BAS), the BAS (in addition to light switches) shall control overall building lighting. Each floor shall be a separate control zone with appropriate subzoning of each floor for special functions.

16.5.2.3 OCCUPANCY SENSORS

Occupancy sensors shall be provided (in addition to switches) to control lighting in offices and smaller rooms, bath and locker areas, and conference rooms.

16.5.3 LAMPS AND BALLASTS

Electrical discharge lamps and high-intensity discharge (HID) lamps should be the primary lamps considered in the selection of the illumination concept. The lighting system shall use, to the maximum extent feasible, energy-efficient fixtures with electronic high-frequency ballasts, T-8 fluorescent lamps, and high-quality light reflectors and lenses. The use of filament light sources should be kept to an absolute minimum (i.e., only in spaces that do not have a need for high levels of illumination, that are normally occupied only for short durations, and for which discharge lamps are not suitable). Where fluorescent lamps will be utilized, these lamps shall be of the T-8 type to conserve energy.

16.5.3.1 INDOOR HID LIGHTING

In using HID lighting indoors, the required color rendition shall be carefully considered from both visual and health safety perspectives.

16.5.3.2 BALLASTS

All ballasts to be used on this project shall be of the energy-saving type (electronic high-frequency ballasts shall be used in all possible locations).

16.5.3.3 LIGHT FIXTURE SELECTION

The selection of light fixtures should involve careful consideration of the quality of construction, ease of maintenance, ease of relamping, efficiency, illumination characteristics, mounting technique, and special purpose characteristics (e.g., vaporproof, explosion-proof, elimination of radio frequency interferences).

16.5.4 EMERGENCY LIGHTING (BATTERY UNITS)

An emergency lighting system shall be provided in accordance with NEC Article 700 and arranged to provide a minimum of 3 footcandles of illumination (measured at floor level) throughout the path of egress, including exit access routes, exit stairways, and other routes, such as exit passageways to the outside of the building.

- Laboratories and large open areas such as cafeterias; assembly areas; large mechanical, electrical, and storage rooms; and open-plan office spaces where exit access is normally through the major portion of the areas shall be provided with emergency lighting. In addition, emergency lighting systems shall be provided in any location where chemicals are stored, handled, or used and in large computer rooms.
- The emergency lighting in laboratory rooms should provide at least 5 footcandles of illumination, measured at the exit access door.
- The type of system used shall be such that it will operate in the event of any failure of a public utility or internal disruption of the normal power distribution system in a building.
- Buildings of seven stories or less may be powered from connections to two separate substations from a reliable public utility. Automatic transfer switching shall be provided for the emergency power supply.
- The emergency lighting shall be connected to a generator, when a generator is provided. In buildings where there is no emergency generator, battery backup shall be provided for egress and emergency lighting. This battery backup may be by unit-type battery fixtures, battery packs in fluorescent fixtures, or use of inverters. Where HID lamps are used (and connected to a generator), a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods.

16.5.5 ENERGY CONSERVATION

EPA seeks to minimize energy use dedicated to electric lighting and the resulting cooling loads through proper use of natural lighting in the facility. In effect, it seeks a well-integrated lighting system for its new buildings that makes optimum use of both natural and artificial lighting sources and balances the buildings' heating and cooling needs. A lighting-power budget shall be determined, in conformance with ASHRAE 90, and strictly adhered to in the design of the lighting for each facility. This budget may be exceeded in laboratory areas and in shops where a higher level of illumination is required because of the type of work being performed.

16.5.6 GREEN LIGHTS

All design of lighting for EPA facilities shall be in accordance with the EPA Green Lights Program.

16.5.7 GLARE

The selection of the type of diffuser and lens to be used on the lighting fixtures shall take into account the glare that can be produced on the work surface. All lighting design shall minimize the effects of glare on the task surface. Indirect lighting shall be used wherever possible.

16.5.7.1 LIGHT FIXTURE LOCATION

In locating lighting fixtures, consideration must be given to the fact that many of the surfaces in the facility (especially in laboratory areas) have highly reflective materials at the task location. Fixtures should be located to keep glare to a minimum.

16.5.8 AUTOMATIC DATA PROCESSING AREAS

Lighting fixture types, location, and illumination levels shall be coordinated with the equipment and functions of the telecommunications, alarm, and automatic data processing (ADP) centers to provide the required illumination without:

- Interfering with prompt identification of self-illuminated indicating devices
- Creating reflecting glare that might detract from adequate observations of essential equipment
- Creating electrical or electromagnetic interference detrimental to proper operation of equipment.

16.6 Fire Safety Requirements for Lighting Fixtures

Lighting fixtures shall comply with the NEC and the following criteria.

16.6.1 MOUNTING

All lamps shall be mounted in a way that prevents direct contact between the lamp and any combustible material. Wherever accidental contact is remotely possible, the lamp shall be protected by a guard, globe, reflector, fixture, or other protective means (NEC Article 410).

16.6.2 FLUORESCENT FIXTURES

All fluorescent fixtures installed indoors shall be provided with ballasts that have integral thermal overload protection (NEC Article 410).

16.6.3 LIGHT DIFFUSERS

Light diffusers shall be either of noncombustible material or of a design or material that will drop from the fixture before ignition. Where combustible dropout-type fixtures are used, plastic material shall not constitute more than 30 percent of the total ceiling area. Where luminous or diffuser ceilings are used, these restrictions also apply.

16.6.4 LOCATION

Lighting in locations where dangerous gases, liquids, dusts, or fibers may exist shall meet the requirements of NEC Article 500.

16.7 Exterior Lighting Systems

16.7.1 GENERAL

Exterior lighting systems shall comply with the IES lighting handbook. System controls shall use a time clock and/or photocell to provide illumination only when needed. In buildings with a BAS (building automation system), exterior lighting shall be switched by photocells in series with timers and the BAS system.

16.7.1.1 EXTERIOR LIGHT GLARE

Light glare shall be kept to a minimum in situations where it would impede effective operations of protective force personnel; interfere with rail, highway, or navigable water traffic; or be objectionable to occupants of adjacent properties.

16.7.1.2 HIGH INTENSITY DISCHARGE LAMPS

Maximum use shall be made of HID lamps such as metal halide or high-pressure sodium vapor lamps.

16.7.1.3 EARLY HOURS LIGHTING

Consideration shall be given to reducing the amount of light in parking lot areas during times (early morning hours 12:00 AM to 4:30 AM) when it is very unlikely that the lots will be in use. EPA personnel at the site shall be contacted before this is made a part of the design.

16.7.2 PARKING LOT LIGHTING

Lighting over driveways and parking areas shall consist of a complete HID lighting system, including control equipment, underground wiring, luminaries, and all necessary accessories for a complete and functioning system. The maintained level of illumination shall be at least 1 to 3 footcandles.

16.7.3 BUILDING FACADE LIGHTING

Appropriate lighting shall be provided at each exterior door and for functional and security illumination of exterior programmed areas.

16.7.4 TRAFFIC CONTROL LIGHTING

If the facility is on a site where traffic controls are necessary and will not be provided by the local municipality or state transportation authority, a complete traffic control system for the facility shall be designed, including all stoplights, directional lights, controls, and wiring, for a complete operating system.

16.7.5 ROADWAY LIGHTING

All new access roadways, or continuations of loop or access roadways, and driveways shall be lighted. The maintained level of illumination shall be at least 1 to 3 footcandles on vehicular roadways and pedestrian walkways. The same type of lighting that is used for parking lots (HID source) shall be used for roadways.

16.7.6 EXTERIOR ELECTRIC SIGNS

All exterior electric signs and nonelectric signs shall be integrated into the total design of the facility and approved by the COR.

16.8 Emergency Power System**16.8.1 GENERAL**

An emergency power system shall be designed and provided for all administrative and laboratory space. The system shall provide electric power in the event of loss of normal power and shall provide power for emergency and egress lighting. The system shall also supply power to critical equipment during planned outages for maintenance. The emergency power system shall comply with NFPA 37, the NEC, NFPA 101, NFPA 110, and IEEE 446.

16.8.1.1 BATTERY-TYPE LIGHTING

In smaller buildings when the emergency power system is installed primarily for egress lighting, battery-type lighting units shall be used.

16.8.1.2 EMERGENCY POWER

In facilities where the emergency power needs are larger than can be handled by battery packs, an emergency generator shall be supplied. This emergency power system shall be composed of a diesel engine-driven generator equipped with phase-synchronized automatic transfer switch or switches and with necessary controls for automatic operation. If the loads and the availability of natural gas allow, a natural gas generator shall be considered. All automatic transfer switches shall be of the isolation/bypass type. The generator(s) shall transfer and pick up the critical load(s) within 10 seconds. The system shall be able to carry a continuous full load for not less than 24 hours. The exhaust and fuel pipe vents shall be arranged and located away from fresh-air intakes. The exhaust shall be located where maximum dilution can be accomplished. The generator shall be designed to handle nonlinear loads plus 25 percent spare capacity. The generator shall be water cooled.

Section 16 - Electrical Requirements

16.8.1.2.1 EMERGENCY POWER REQUIREMENTS

Table 16.8.1, Emergency Power Requirements, outlines the emergency power requirements for different building heights and particular fire safety systems. Generators are not required by these criteria unless an analysis of the cost of installation and maintenance of acceptable emergency power sources shows that a generator is the most cost-effective power source. Automatic switching schemes shall be provided for all emergency power sources. Where emergency generators are used, their installation shall be in accordance with NFPA 110 and NEC Article 700.

Table 16.8.1 Emergency Power Requirements

Emergency System	Acceptable Sources of Emergency Power*	
	Building Height [†] 75 Feet or Less	Building Height [†] Over 75 Feet
Emergency lighting (1½ hours)	1, 2, 3	1, 3
Exit lighting (1½ hours)	1, 2, 3	1, 3
Fire alarm	1, 3	1, 3
Fire pump	N.R.	1, 2
Jockey pump	N.R.	1, 2
Elevator	N.R.	1, 2*
Smoke control	—	N.R.
Sprinkler system air compressor	N.R.	N.R.
Special extinguishing system power supply (dry chemical, CO ₂ , or other EPA-approved system)	N.R.	N.R.
Fume hoods (full or partial containment or where deemed necessary)	1, 2	1, 2

Note: 1 = Generator; 2 = Connection either to two separate primary sources or to a utility network system; 3 = Battery with charger; N.R. = Not Required.

* Power source must be capable of providing power to one elevator on a selective basis when the building contains six or fewer elevators. Otherwise, two elevators must be supplied on a selective basis.

[†] The building height for application of the criteria shall be determined by measurement of the distance from grade level of the lowest accessible floor to ceiling height of the highest occupied floor in the building. Mechanical rooms and penthouse are not considered occupied floors in this case.

16.8.1.3 EMERGENCY GENERATOR LOCATION

The preferable location for the generator is outdoors. The location should be such that the generator will be hidden from view and should be to the rear of the main facility. The generator should be placed over vibration isolators and should make use of noise dampers and other devices, as required, to substantially attenuate noise and vibration resulting from its operation. The generator shall be equipped with a low-noise exhaust silencer (hospital or critical type) and weatherproof housing.

16.8.1.4 ECONOMIC ANALYSIS

For all installations where a generator is provided, an economic analysis shall be done to determine the economic feasibility of including load-shedding or peak-shaving equipment as part of the installation. EPA will provide instructions on the possible inclusion of this item in the project after the economic analysis has been completed.

16.8.1.5 FUEL STORAGE TANK

If a diesel-type generator is used, the system shall be provided with a fuel storage tank that is capable of carrying a continuous full load for not less than 24 hours. The preferred type of tank is an aboveground storage tank. If allowed by EPA, the tank may be installed underground. If so, the tank

shall be of double-wall construction and of noncorrosive material with interstitial monitoring capabilities. The tank shall meet all of the interim prohibition (40 CFR §280.1) requirements or the most current promulgated rules effective on the date of installation. Cathodic protection shall be installed for protecting all metal parts of underground fuel storage tanks.

16.8.2 EMERGENCY LOADS

In addition to the loads required by NFPA 101, NEC, and the room data sheets, the following loads shall be connected to the emergency power system:

- One receptacle in each laboratory
- Fire alarm system
- Exit lights
- Emergency lighting system—3 footcandles minimum for egress; 10 footcandles at switchboards
- Special laboratory equipment
- Telephone relay system
- Controlled-temperature rooms
- Certain HVAC systems (as required by the applicable state and local codes and as directed by EPA)
- Critical sump pumps and other associated mechanical equipment and controls
- All animal care facilities
- Local HVAC air compressors for special rooms
- Paging system
- Selected elevators (as required by the applicable state and local codes and as directed by EPA)
- Gas chromatograph
- Selected refrigerators and freezers (as directed by EPA)
- Incubators
- X-ray fluorescent analyzer
- UPS system
- Air-conditioning system associated with computer rooms and environmental rooms
- Security systems
- Safety alarm systems.

16.8.3 UNINTERRUPTIBLE POWER SUPPLY

A UPS system shall be provided for loads requiring guaranteed continuous power. The application of UPS systems shall comply with IEEE 446. UPS equipment can be of the rotary or stationary type. A recommendation shall be made concerning the appropriate type of system for a particular facility. UPS equipment shall be provided with multiple power supplies (normal power, static switch bypass power, and total system bypass power). The UPS system shall be sized to provide at least 5 minutes of protection upon loss of normal power. Total system bypass power shall include an isolation transformer. All components shall be UL listed. The supplied UPS system shall be specified to operate properly with an emergency generator.

16.8.3.1 MINIMUM REQUIREMENTS

The UPS system shall operate continuously and in conjunction with the existing building electrical system to provide precise power for critical equipment loads. The static system shall consist of a solid-state inverter, a rectifier/battery charger, a storage battery, a static bypass transfer switch, synchronizing circuitry, and an internal maintenance bypass switch. The rotary system shall include a solid-state inverter, a battery charger, a storage battery, an automatic transfer assembly, an internal (automatic) bypass switch, and a low-voltage transient synchronous generator. The UPS system, along with the supporting equipment, shall be housed in dedicated room(s) under controlled environmental conditions that meet the manufacturer's recommendations and code requirements.

16.8.3.2 CODES, STANDARDS, AND DOCUMENTS

The UPS shall be designed in accordance with the applicable codes and standards of the following:

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- NEMA
- IEEE inverter standards
- ASA
- American Society of Mechanical Engineers (ASME)
- National Electrical Code
- Occupational Safety and Health Administration (OSHA)
- Local codes.

16.8.3.3 ON-LINE REVERSE TRANSFER SYSTEM

The UPS shall be designed to operate as an on-line-reverse transfer system in the following modes:

- Normal (Static). The critical load shall be continuously supplied by the inverter. The rectifier/battery charger shall derive power from the utility alternating current (AC) source and supply direct current (DC) power to the inverter while simultaneously float-charging the battery.
- Normal (Rotary). The critical load shall receive power from the utility company to the motor-generator set, which powers the critical load and charges the batteries.
- Emergency (Static). Upon failure of the utility AC power source, the critical load shall be supplied by the inverter, which, without any switching, obtains its power from the storage battery. There shall be no interruption to the critical load upon failure or restoration of the utility AC source.
- Emergency (Rotary). Upon failure of the utility AC power source, the control logic shall turn on the inverter and provide AC power from the battery to the motor-generator set and from the motor-generator set to the critical load. The inverter shall be capable of full-power operation within 50 milliseconds after loss of utility power.
- Recharge. Upon restoration of the utility AC source (prior to complete discharge of the battery), the rectifier/battery charger powers the inverter and simultaneously recharges the battery. This shall be an automatic function and shall cause no interruption to the critical load.
- Bypass mode. If the UPS must be taken out of service for maintenance or repair of internal failures, the static bypass transfer switch shall be used to transfer the load to the alternate source without interruption. Automatic retransfer or forward transfer of the load shall be accomplished after the UPS inverter synchronizes to the alternate bypass AC input source. Once the sources are synchronized, the static bypass transfer switch shall forward transfer the load from the bypass input source to the UPS inverter output by paralleling the two loads and then disconnecting the bypass AC input source. Overlap shall be limited to one-half cycle.
- Maintenance bypass/test. Internal switches shall be provided to isolate the UPS inverter output and static bypass transfer switch output from the AC bypass input source and the load. The switches, in conjunction with the static bypass transfer switch, shall enable the load to be reverse-transferred from the UPS inverter output to the AC bypass input source without interruption. The switches shall enable the UPS inverter and static bypass transfer switch to be tested without affecting load operation.
- Downgrade. If only the battery will be taken out of service for maintenance, it shall be disconnected from the rectifier/battery charger and inverter by means of an external battery disconnect. The UPS shall continue to function as specified herein, except for power outage protection and transient characteristics.

16.8.3.4 UPS OUTPUT

The UPS output shall have the following characteristics:

- Frequency: 60 hertz (Hz) nominal +0.5 Hz (when synchronized to the bypass AC input source).
- Output voltage transient characteristics for:
 - 25 percent load step change +4 percent
 - 50 percent load step change +6 percent
 - 100 percent load step change +10 percent/-8 percent.
- Output voltage transient response: The system output voltage shall return to within +1 percent of the steady state value within 30 milliseconds.
- Output voltage regulation: The steady state output voltage shall not deviate by more than +1.0 percent from no load to full load.

16.8.3.5 OUTPUT FREQUENCY REGULATION

The UPS shall be capable of providing the nominal output frequency +0.1 percent when the UPS inverter is not synchronized (free running) to the AC bypass input line.

16.8.3.6 SYSTEM OVERLOAD

System overload is a load of at least 125 percent of the system rating for a period of 10 minutes, and 150 percent current for 1 minute. Overloads in excess of 170 percent of the UPS rating, on an instantaneous basis, or in excess of the overload time periods previously stated shall cause the static bypass transfer switch to reverse-transfer and allow the AC bypass input source to supply the necessary fault-clearing current. After approximately 5 seconds, the static bypass transfer switch shall automatically forward-transfer, and normal UPS operation shall resume. If the overload still exists after the 5-second period, the static bypass transfer switch shall automatically reverse-transfer the load to the AC bypass input source and the UPS inverter shall turn off. The system shall require manual restart after this sequence.

16.8.3.7 SYSTEM EFFICIENCY

The overall efficiency, input to output, shall be at least 95 percent with the battery fully charged and the inverter supplying full-rated load.

16.8.3.8 LOCATIONS AND LOADS

The UPS system shall be located in special rooms or in the same room as computer equipment. These rooms shall have special HVAC equipment to maintain the proper environmental conditions for the UPS system and its batteries both under normal conditions and during a power outage.

16.8.3.8.1 UPS LOAD

The UPS load will consist of the equipment and outlets designated for UPS power connection in the room data sheets.

16.8.3.8.2 BATTERY ROOM

The battery room for the UPS shall be well ventilated so as not to allow an explosive mixture of hydrogen to accumulate. A minimum air change rate of six air changes per hour is required. These battery rooms shall contain all devices required by the *Safety Manual* (including mechanical ventilation, an emergency eyewash station, and a fire/smoke sensing device). An exhaust fan, roof ventilator, or ducted in-line fan should be used for ventilation. The fan shall be connected to the normal (e.g., utility) power system. Makeup air shall be provided and should be filtered. The mechanical ventilation system for a UPS room shall be monitored to ensure that any failure is detected promptly. The system may be designed so that failure triggers a warning from the fire alarm system of an audible alarm at a constantly attended location. The ventilation requirements in this subsection are not meant to apply to sealed battery units that are provided for specific equipment. The installation of the UPS system shall be in accordance with NFPA 111. An

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emergency eyewash station, isolated from electrical power sources, shall be provided in battery rooms required in battery rooms. A fire- or smoke-sensing device shall be installed in battery rooms.

16.9 Lightning Protection System

MINIMUM SCOPE

A
for facilities containing radioactive or explosive materials. The requirements and installation criteria for protection systems shall be in accordance with NFPA 780, UL 96A, and the local building code.

16.9.2

For building types not in the above description, the guide in NFPA 780 shall be used to assess the risk of

16.9.3 MASTER LABEL

buildings described in subsection 16.9.1 and for facilities with a strong risk potential (per NFPA 780), equipment,
for all building components should be furnished and installed. The system shall comply with NFPA 780, 96A, and Lightning Protection Institute (LPI) 175. All cables, lightning rods, and accessories shall be copper. All connections and splices shall be of the exothermic weld type.

MINIMUM REQUIREMENTS

The
concealed). The system shall also be properly flashed and watertight. Installation shall be done in

16.9.3.2 CERTIFICATION DELIVERY

the lightning protection system is accepted, the contractor shall obtain and deliver to the supervising architect the UL master label or an equivalent certification.

Seismic Requirements

16.10.1

The design and construction of all new EPA facilities shall comply with those standards and practices that substantially equivalent to, or exceed, the National Earthquake Hazard Reduction Program (NEHRP) Recommended Provisions for the Development of Seismic Regulations for New Buildings.

Automatic Data Processing Power Systems

16.11.1

Adverse effects that voltage level variations, transients, and frequency variations may have on ADP shall be minimized. ADP equipment shall be isolated as needed for protection. UPS or power distribution units (PDUs) may be used for isolation.

COMPUTER POWER

All computer power shall
or PDUs that have monitoring capabilities with some transient protection. PDU shall limit the cable runs

to 100 feet from the PDU to the ADP equipment. The user will provide a list of equipment cable types and plug types. All circuits shall have separate neutrals. All UPS units and PDUs shall be connected to a central monitoring and control system.

16.11.3 POWER PANELBOARDS AND DISTRIBUTION PANELS

All individual power panelboards not exceeding 200 amperes shall have meters for the main breaker, with readouts on panel. All main distribution panels shall have meters on all breakers. Non-UPS/PDU outlets shall be spaced every 20 feet around the computer room for utility use (vacuums, drills, etc.).

16.11.4 LIGHTING

Under-floor lights with cutoff timer(s) shall be installed in computer room(s). Room lighting for computer rooms shall be either indirect lighting, to reduce glare on terminal screens, or overhead lighting of the parabolic type, to reduce eye strain.

16.11.5 GROUNDING

All computer power shall be grounded to a large single-point ground within the raised floor system grid (bolt-in type).

16.12 Cathodic Protection

16.12.1 INVESTIGATION AND RECOMMENDATION

An investigation shall be conducted and a determination made, on whether cathodic protection is required for buried utilities. If a cathodic protection system is required, a system shall be recommended to satisfy the local conditions. The cathodic protection system shall be designed by a design professional who is National Association of Corrosion Engineers (NACE) certified and has 2 to 3 years' experience in similar installations.

16.13 Environmental Considerations (Raceways, Enclosures)

16.13.1 CORROSIVE ATMOSPHERE

Special consideration shall be given to the type of raceways to be used in corrosive environments (such as chemical storage areas, some laboratories, and areas near air-handling exhausts for spaces with corrosive fumes). All raceways to be used in corrosive atmospheres shall be deemed suitable by the raceway manufacturer for the atmosphere in which they will be installed.

16.13.1.1 EQUIPMENT ENCLOSURES

The enclosures for electrical equipment (e.g., panels, switches, breakers) shall have the proper NEMA rating for the atmosphere in which the equipment is being installed.

16.13.2 SALTWATER ATMOSPHERE

Careful consideration shall be given to the type of materials to be used for exterior electrical work (including lighting) when the facility is located near or in a coastal area. Salt air can have a detrimental (corrosive) effect on steel and any painted electrical surfaces. The use of EMT or any thin wall raceways in the interior of the building should also be weighed carefully because storage of these materials outside of the building (or storage or installation in the building before it is fully enclosed) could result in corrosion.

16.13.3 EXTREME COLD

Electrical equipment such as emergency generators, transformers, and switch gear installed in weatherproof enclosures of the facility that are subject to extremely cold temperatures should be provided with supplemental heating within the enclosures.

16.13.4

In all areas where atmospheres contain combustible materials, all electrical equipment, including raceways, and boxes, shall be designed in accordance with NEC Article 500. Steps shall be taken to control or eliminate static electricity in areas where materials that are ignitable by static spark discharge are propellants, and pyrotechnics, as exhaust fans that are exhausting areas containing combustible materials shall also be designed in accordance

16.13.5 FLOODPLAIN AREAS

equipment shall not be located below grade in facilities sited in floodplain areas. Emergency generator equipment (floor mounted) located at grade level in floodplain areas shall be placed on at least 6 inches of

16.14 Communication Systems**TELECOMMUNICATIONS/DATA SYSTEMS**

All Wiring/Telecommunication Guidelines.”

16.14.2

Designated video conference rooms must be supported by communication wiring specified in AT&T's Advisory-T1.5 Premise Wiring Requirements and “FTS-2000 Switched Digital Video Guidelines for teleconference space (CVTS) communication wiring should be limited to 300 unrepeat cable runs. The interface (service delivery point) to support CVTS rooms will be located in the network control facility access for 22-gauge shielded solid copper twisted-pair wire. Longer runs may require repeaters and require expenses, but they must remain within the 1.5-decibel loss specifications of the technical advisory manuscript concerning the wiring.

RECORDING SYSTEMS

In areas where conferences are to be recorded, built-in microphones shall be provided containing the recording equipment. Wiring shall be installed from the microphone (omnidirectional) to

16.14.4 SATELLITE DISHES

area may be required for the installation of satellite dishes that will be used for telecommunications, television dish head-in equipment (receivers and transmitters). Where use of a satellite dish is required, power shall be furnished for all head-in equipment. Cable raceways shall be provided from the satellite dish location to the room for the head-in equipment and from the head-in equipment to each outlet served and to the

16.14.5 TELEVISION BROADCAST SYSTEMS

In facilities from which a local or national television station will be broadcasting live meetings or press conferences, a complete raceway (or cable-tray) system shall be furnished to allow the station to run cables from the designated television van parking areas to the conference/press room. If cable tray is provided, it shall be completely accessible throughout its length.

16.14.5.1 WEATHERPROOF RECEPTACLES/DISCONNECT SWITCHES

In addition, weatherproof receptacles or disconnect switches (fused) shall be provided at the van parking areas to allow each van to receive power from the building.

16.14.6 MICROWAVE COMMUNICATIONS

Where required, an area shall be designed for the installation of a microwave dish that will be used for telecommunications or data transmission. An area shall also be designed for microwave head-in equipment. Power shall be furnished for all head-in equipment. Cable raceways shall be provided from the microwave dish location to the room for the head-in equipment and, from there, to the room where the controller will be located. All equipment and cables will be furnished by EPA.

16.14.7 OTHER

A complete raceway system shall be furnished for other communication/data systems (systems not otherwise mentioned in subsection 16.14). The raceway system shall include raceways, outlet and junction boxes, and power connections (direct or receptacle) for all associated equipment to be located in the facility. Unless otherwise directed by EPA, all cabling and equipment for these other systems will be furnished by EPA.

16.15 Alarm and Security Systems**16.15.1 FIRE ALARM SYSTEM**

Fire alarm systems must be installed in accordance with NEC Article 760. Devices that activate fire alarm systems and evacuation alarms must be completely separated from other building systems such as environmental monitoring systems and security systems. Other features of the fire alarm system (e.g., fan shutdown) may be shared with these other building systems, but the performance of the fire alarm system must not be compromised and must meet the requirements stated in this subsection. In general, auxiliary functions, such as elevator recall and smoke control, are not performed by the fire alarm system but by other mechanical or electrical systems. The main fire alarm system should supervise any auxiliary system (e.g., computer room). Activation of the main fire alarm shall also activate the audible (and visual, if applicable) devices of the auxiliary system in the associated alarm area. The fire protection system shall be in compliance with the most current codes and publications, as listed below (see other sections for additional codes and standards):

- Sprinkler Systems, NFPA 13
- Standpipe and Hose Systems, NFPA 14
- National Fire Alarm Code, NFPA 72
- GSA/PBS-PQ100
- ADA Requirements
- *Safety Manual*, Chapters 2, 3, and 5.

16.15.1.1 BASIC REQUIREMENTS

In any office, computer room, library, classroom, cafeteria, or similar business-type occupancy, fire alarm systems are required if the occupancies have any of these characteristics:

- The occupancies are two or more stories above the level of exit discharge.
- The occupancies may have 100 or more occupants, above or below grade.
- The occupancies consist of more than 50,000 square feet.
- A human voice, gas-powered horn, or other similar nonelectric system cannot efficiently or effectively be used to alert occupants to an emergency.

Storage occupancies equal to or larger than 100,000 square feet shall have fire alarm systems. All other occupancies shall follow the requirements in NFPA 101.

16.15.1.2 MANUAL SYSTEMS INPUT

Each system shall provide manual input from manual fire alarm stations, which shall be located in exit or public corridors adjacent to each stairway and to each exit from the building. Additional stations may be provided at any location where there is a special risk or where the travel distance to the nearest station exceeds 200 feet. As a general principle, the station shall be placed so that a person using it will be between the fire and the exit. If necessary, emergency telephone systems shall be provided in the exit stairs or in another protected location, as indicated for manual fire alarm stations. In addition, telephones shall be provided at each elevator lobby, at the ground floor, and on alternate elevator-capture floors.

16.15.1.3 AUTOMATIC SYSTEMS INPUT

Automatic fire detection shall be provided as described below.

- A water flow switch shall be provided for each floor or fire area protected by wet-pipe sprinkler systems. Other types of sprinkler systems will be activated by a pressure switch at the dry or deluge valve only.
- Automatic heat or smoke detection shall not be installed in lieu of automatic sprinkler protection unless this decision is otherwise supported through recognized equivalency methodologies (NFPA 101M). Detection shall be provided where a preaction or deluge sprinkler system exists. Automatic sprinkler protection requirements are described in Section 15, Mechanical Requirements, of this Manual.
- Smoke detectors shall be provided for essential electronic equipment (NFPA 72, Chapter 7), air-handling systems (NFPA 72, Chapter 5), and elevator lobbies and machine rooms (NFPA 72, Chapter 5). All smoke detectors shall be approved for their intended use and installation. Smoke detectors require periodic maintenance, and arrangements for this should be made at the time of installation to ensure proper operation and to guard against false alarm or unintended discharge.
- Heat and smoke detection in air-handling systems shall comply with NFPA 90A. Detectors, when required, shall be located in the main supply duct downstream of a fan filter and in the return air ducts for each floor or fire area.
- When heat and smoke detectors are installed, they shall be designed and installed in accordance with NFPA 72.
- Special hazard protection systems shall initiate an alarm. These special systems include, but are not limited to, dry chemical extinguishing systems, elevator recall systems, and computer detection systems.
- Supervisory signals shall be transmitted under each of the following conditions:
 - Operation of generator
 - Operation of fire pump
 - Loss of primary power to a fire alarm system, fire pump, or extinguishing system
 - Loss of air pressure for dry-pipe sprinkler system
 - Loss of a central processing unit (CPU) or of CPU peripheral equipment in a multiplex system
 - Low water level in pressure tanks, elevated tanks, or reservoirs
 - When control valves in the supply or distribution lines of automatic sprinkler systems, fire pumps, standpipe systems, or interior building fire main systems are closed either a maximum of two complete turns of a valve wheel or 10 percent closure of the valve, whichever is less. (In this case, the signal will be transmitted by tamper switches.)

16.15.1.4 AUTOMATIC SYSTEMS OUTPUT

In all buildings, the primary alarms to the occupants and the fire department, and other critical signals or activation of emergency equipment shall be initiated automatically. In no case shall these alarms depend on manual action. Various outputs include those listed below.

- Elevator control smoke detector actuation shall sound an alarm at the fire alarm panel, recall elevators, and notify the fire department but shall not initiate an audible alarm signal to building occupants or start any smoke control system, except as noted below. The smoke detector alarm signal shall be received at a central station or some other location that is constantly attended. This will ensure an investigative response to the alarm.
- General area smoke detectors shall initiate an evacuation alarm for the portion of the building or area in which they are used to increase the level of protection. In such situations, smoke detectors and fire alarm panels equipped to provide alarm verification may be desirable.
- All alarm signals or messages shall be continuous. Where public address systems are provided for the facility, there shall be provisions for making announcements from the main fire alarm panel or from an attended location where the fire alarm signal is received. The public address system does not have to be an integral part of the fire alarm system. Coded alarm signals are unacceptable.
- The output of special extinguishing systems, such as those provided for kitchens, shall include the actuation of the building fire alarm system. Special detection systems shall indicate a supervisory signal at the fire alarm panel.
- If an entire building can be evacuated within 5 minutes, the fire alarm shall sound either throughout the building or on selected floors. Where selective evacuation is used on the basis of local code requirements, features such as smoke control and automatic sprinklers shall be provided, as necessary, to ensure the safety of occupants remaining in the building.
- For voice communications systems, only the occupants of the fire floor, the floor below, and the floor above are expected to relocate or evacuate. These occupants must automatically receive that message and be notified of the emergency. Where automatic prerecorded voices are used, message arrangement and content shall be designed to fit the needs of the individual building (e.g., bilingual messages where appropriate).
- The use of visual signals to supplement the audible fire alarm system shall be provided in accordance with NFPA 72 and Title III standards of ADA.
- Every alarm reported on a building fire alarm system shall automatically actuate one of the following:
 - A transmitter approved by UL, connected to a privately operated, central-station, protective signaling system conforming to NFPA 72. The central-station facility shall be listed by UL; automatic telephone dialers shall not be used.
 - An auxiliary tripping device connected to a municipal fire alarm box to notify the local fire department, in accordance with NFPA 72.
 - A direct supervised circuit between a building and the local fire alarm headquarters or a constantly manned fire station, in accordance with NFPA 72.
 - As a last resort, an alternate method approved by SHEMD.

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- Notification of the fire department shall occur no more than 90 seconds after the initiation of an alarm. The specific location of the alarm may be determined by fire department personnel after they arrive.
- A supervisory condition shall transmit a separate signal to a central station, different from an alarm signal. No more than one supervisory signal shall be provided for an entire building. Refer to the automatic systems input information in subsection 16.15.1.3 above for required supervisory conditions.
- Additional automatic actions shall be performed for smoke control, elevator capture, and door closings. Smoke control and elevator capture shall be coordinated with the evacuation plan for a building. (A summary of system actions is shown in Table 16.15.1.)

Table 16.15.1 Status Condition

Output Function	Input Device					
	A	B	C	D	E	F
Transmit signal to fire department	X	X	X	X	X	
Indicate location of device on control panel and annunciator	X	X	X	X	X	X
Cause audible signal at control panel	X	X	X	X	X	X
Initiate emergency operation of elevators	X	X*		X		
Initiate smoke control sequence	X			X		
Result in a record on system printer	X	X	X	X	X	
Cause audible alarm signal throughout building (voice or nonvoice)	X			X		

A = Manual fire alarm station

D = Water flow detectors and automatic extinguishing systems

B = Smoke detectors (other than duct)

E = Supervisory device

C = Duct smoke detectors

F = Emergency telephone

Note: Only smoke detectors associated with the elevators (e.g., the elevator lobby) must initiate elevator emergency operation.

16.15.1.5 MANUAL SYSTEMS OUTPUT

Any action that can be performed automatically must be able to be initiated manually from the control center or fire alarm system control panel. A smoke control panel shall be provided when smoke control systems are required. The control center, or fire alarm system control panel, shall have the capability of canceling and restoring any action that has been initiated automatically or manually.

16.15.1.6 SYSTEMS FEATURES

All systems shall include the following:

- Indication of normal or abnormal conditions
- Annunciation of alarm, supervisory, or trouble conditions by zone
- Graphic annunciation of alarm conditions by zone
- Ringback feature when a silence switch for audible trouble signal is provided.

16.15.1.7 HIGH-RISE SYSTEMS FEATURES

For buildings 12 stories tall or higher, the systems shall also include the following:

- Permanent record of alarm, supervisory, or trouble conditions via printer
- Initiation of an alert tone followed by a digitized voice message.

All power supply equipment and wiring shall be installed in accordance with the requirements of NEC and NFPA 72.

16.15.1.8 RELIABILITY

The maximum amount of time from actuation of a system input device to initiation of all system functions shall be 10 seconds. Any system alarm input device shall be capable of initiating an alarm during a single break, or a single ground fault condition, on any system alarm-initiating circuit (Class A feature, Style D or E). In addition, any signaling line circuit of a multiplex system (other than combination multiplex-point wired systems) shall also perform its intended service during a wire-to-wire short or a combination of a single break and a single ground of a circuit (Class A feature, Style D or E).

16.15.1.9 CODE COMPLIANCE, MANUAL SYSTEM

A complete, code-complying fire alarm system shall be designed. For small buildings, and where allowed by code, the system may be a manual system only. The manual system shall include manual stations, fire alarm annunciator signals, and an annunciator panel indicating the zone where the alarm was initiated. The alarm shall be sent to the local fire station.

16.15.1.10 CODE COMPLIANCE, AUTOMATIC SYSTEM

In large facilities, or where required by code, the systems shall be automatic and shall include smoke detectors, manual pull stations, rate of rise detectors, alarm bells or horns and strobe lights, sprinklers, and a central annunciator panel. Suppression systems shall be tied to the central annunciator panel. The fire alarm system shall be tied to the local fire station in the area. Smoke detectors shall be provided in all corridors and designated laboratory modules.

16.15.1.11 CENTRAL, LOCAL, AND PROPRIETARY ALARM SYSTEM

The building(s) shall be protected by a central, local, proprietary-type fire alarm system. Location of pull stations, bells, automatic fire detectors, and other equipment pertinent to the fire alarm system shall be in accordance with the referenced NFPA and local codes. When there is a difference between the NFPA codes and local codes, compliance with the most stringent code will be required. Visual alarms are required throughout the facility for handicapped fire warning. The system shall meet GSA requirements for fire alarms and communication systems, as contained in Chapter 18 (Electrical) of the GSA Fire Safety Criteria.

16.15.1.12 CENTRAL STATION SERVICE

The building(s) shall be protected by local fire alarm system(s) connected to either a UL-listed central station or central station service (NFPA 72).

16.15.1.13 SYSTEM GENERAL REQUIREMENTS

Pull stations shall be installed adjacent to all exit stair doors. Actuation of a manual station shall set off an alarm throughout the building, as required, and shall send a manual station alarm signal to the local fire department through a central station service. Actuation of any suppression system (sprinkler, dry/wet chemical) protecting the building and its occupants shall set off an alarm as described for pull stations, but will send a suppression signal to the central station service. All valves on the building's sprinkler system and/or standpipe systems shall be supervised by the fire alarm control panel. The closure of a valve shall initiate a supervisory signal to the building's fire alarm control panel and to the central station service. Low-air-pressure switches on dry-pipe sprinkler systems and low-nitrogen-pressure switches on preaction sprinkler systems shall be supervised by the building's fire alarm control panels. The closure of these normally open supervisory switches shall initiate a supervisory signal to the building's fire alarm control panels and to the listed central station service. Elevator lobby smoke detection systems shall be incorporated into zones labeled "Elevator Smoke Detector" and shall actuate a prealarm signal in the fire alarm control panel and send a prealarm signal to the central station service. Likewise, elevator lobby smoke detectors shall be monitored for trouble by the building fire alarm system. Smoke detector systems and subsystem(s) shall be connected to actuate a prealarm signal

to a central station service. These panels shall also be monitored for trouble by the building fire alarm system. Visual and audible alarm signals are required throughout the facility.

16.15.1.14 FIRE ZONES

Building(s) shall be subdivided into fire zones as recommended by NFPA and local codes. Graphic annunciators shall be provided at the main entrances and the security control center. These annunciators shall clearly show the outline of the buildings, the fire zones, and the alarm-initiating devices. Alarm signals shall be transmitted directly to a UL-listed central station service.

16.15.1.15 WIRE CLASS AND CIRCUIT SURVIVABILITY

The fire alarm system-initiating device circuits shall be wired Class A, and alarm-indicating circuits (visual and audible) shall be wired Class A (NFPA 72). All initiating and indicating circuits shall be wired to be survivable, as defined in paragraph 13.i, Chapter 18, of the *GSA Fire Safety Criteria*.

16.15.1.16 CONTROL CENTER

Building(s) must have a control center where fire-related control panels are located. This control center must be located next to the main entrance and shall be separated from the rest of the building by 1-hour fire resistive construction. Emergency lighting must be provided. Air-handling, lighting, and fire protection systems for the emergency control center must be arranged to operate independently of the effects of fire anywhere in the building.

16.15.1.17 SYSTEM AND OPERATION STANDARDS AND CODES

The fire alarm system and its operation shall be in accordance with NFPA standards, local codes, and the requirements of GSA handbook PBS-PQ100, *Facilities Standards for the Public Building Service*.

16.15.1.18 SIGNAL DEVICES

Signal devices shall include pull stations, heat and smoke detectors, and signals from the sprinkler system fire pump (if required). Smoke detectors shall be provided in the spaces described above, in all corridors, elevator lobbies, air-handling equipment, and ductwork, and in special spaces as described in the room data sheets. Heat detectors shall be provided in all mechanical equipment rooms, and in electrical rooms. All signal devices shall be addressable (i.e., each device shall have its own address, which shall report to monitoring devices in the English language for clear and quick identification of the alarm source). The fire alarm central panel shall report the various signals, defined to suit smoke purge requirements, to the direct digital control (DDC) portion of the building automation system, which, in turn, will sequence fans and smoke dampers to meet the smoke control requirements. The fire alarm central panel shall be able to adjust the sensitivity of all smoke detectors.

16.15.1.19 HELD-OPEN FIRE DOORS

Fire doors that are normally held open by electromagnetic devices should be released by the action of any automatic detection, extinguishing, or manual alarm signaling device. Additional information on door requirements may be found in Section 8, Doors and Windows, of this Manual. Maintenance, operation, testing, and equipment shall conform to NFPA 72, National Fire Alarm Code.

16.15.1.20 ELECTRICAL SUPERVISION/EMERGENCY POWER

The fire alarm wiring and equipment must be electrically supervised. Emergency power must be provided and must be able to operate the system in the supervisory mode for 48 hours and to operate all alarm devices and system output signals for at least 90 minutes. All alarm-initiating devices, except smoke detectors, must be capable of signaling an alarm during a single break or a single ground fault.

16.15.2 SAFETY ALARM SYSTEM

Requirements for this system are as follows.

16.15.2.1 ANNUNCIATOR PANEL

A central safety alarm system annunciator panel that will indicate any abnormal condition shall be designed for the facility. The annunciator panel shall include all relays, switches, and controls, as required for system operation. The basic operation of the panel shall indicate any abnormal condition in a function supervised by the annunciator system, causing the associated indication to flash and the common audible signal to sound continuously. The audible signal can be silenced at any time by the operation of an "acknowledge" push button. The audible signal will automatically sound again with any new indication. The visual signal shall become steady when acknowledged.

16.15.2.2 INDICATING PLATES

Indicating plates shall be red with filled-in place characters. All lamps in the annunciator are tested simultaneously by pressing the remotely mounted "Lamp Test" push button. The annunciator shall indicate the following systems and equipment statuses:

- Fire alarm initiation
- HVAC system motors alarms
- Emergency generator running
- Freezer and cold box temperature alarms
- UPS system failure
- Fume hood and bio-safety cabinet alarms (critical low-flow)
- Location of activated detection, extinguishing or manual alarm device
- Exhaust hood and ventilated cabinet failure alarms (critical low-flow)
- Exhaust systems for instrument and safety cabinet failure alarms (critical low-flow)
- Acid neutralization system alarms
- Power failure
- Incubator temperature alarm
- Gas alarm
- Sensor (gas) alarm
- Laboratory negative pressure failure alarm
- Additional systems to be identified by the agency.

16.15.3 SECURITY SYSTEMS

General requirements and requirements for particular types of systems and facility and site areas are as follows.

16.15.3.1 GENERAL

A complete security system shall be designed for the facility. All security systems shall be operated and monitored from a central point selected by EPA. All security systems shall have a primary and an emergency power source.

16.15.3.1.1 STANDBY BATTERIES

Standby batteries or a UPS shall be furnished to power the system automatically in the event of commercial power failure. If the facility has a generator, batteries shall ensure that there is no loss of power to central equipment until the generator takes over. An alarm shall not be generated when the equipment transfers from AC to DC operation as it does from DC to AC operation. If the facility does not have an emergency generator, sufficient batteries shall be provided to power the controller and necessary devices to prevent unauthorized entry into the building (electronic locks shall stay in the locked position upon power loss but shall still allow emergency egress). Batteries shall be chargeable. If batteries lose charge, an alarm condition shall indicate this at the control console.

16.15.3.1.2 CONDUIT OR RACEWAY

All wiring shall be in conduit or surface metal raceway.

Section 16 - Electrical Requirements

16.15.3.2 ACCESS SYSTEMS

A complete building access system shall be designed; this system shall be of the on-line type that reports to a central controller. The professional designing this system shall have at least 2 to 3 years of experience in the design of similar installations.

16.15.3.2.1 KEY CARD CONTROL

Key card control shall be provided for all entry to the facility. The key card reader should read key cards with numbering encoded within the card. The card reader shall be capable of operating in an off-line mode to allow persons to enter and exit without recording of card numbers. The card reader shall also be capable of operating in an on-line mode, which causes the card reader to report into a central controller that provides additional security checks on the key card and provides a printout of time, date, card number, etc., for the person entering or leaving the premises. The system shall be of the anti-passback type. In addition, one key access lock and card reader shall be furnished inside the building for every 5,000 square feet of gross floor area (in addition to the vestibules) and at entry to controlled computer areas.

16.15.3.2.2 COMPUTERIZED ACCESS CONTROL SYSTEM

The computerized access control system shall be capable of programming access cards by hour and day. The system shall be designed with 50 percent spare capacity for both card readers and number of cards on the system. Key cards, once removed from the system, shall be replaceable without lowering the integrity of the system or reducing the system's capacity.

16.15.3.2.3 PROXIMITY TYPE CARD READERS

Card readers shall be of the proximity type and shall be suitable for the environment in which they will be located.

16.15.3.2.4 PROGRAMMABLE KEY PAD, SMALL FACILITIES

For very small facilities, a programmable keypad may be used at each entry to control access to the system. The keypad shall be suitable for the environment in which it will be located.

16.15.3.3 INTRUSION DETECTION SYSTEMS

A design professional with a minimum of 2 to 3 years' experience in the design of similar installations shall design a complete intrusion detection system. The intrusion detection system shall protect all grade level doors, operable windows, and openings leading into the facility, as well as roof hatches and roof access doors. Operable windows shall be lockable and accessible windows shall be equipped with an alarm. Roof access doors or hatches shall be secured with heavy-duty hardware and equipped with an alarm. All floor telecommunications closets shall be locked with dead bolt locking devices. In addition to installing perimeter protection, the design professional shall equip a minimum of 10 interior doors with an alarm, as designated by EPA. Door switches shall be of the balanced magnetic type.

16.15.3.3.1 CENTRAL CONTROL, REMOTELY MONITORED

The entire system shall be monitored at the central control desk of the facility and remotely monitored either on the campus, by an alarm company, or by the local law enforcement agency.

16.15.3.4 SITE ACCESS SYSTEMS

One alarm zone with an infrared beam shall be provided to monitor vehicles passing through the gate of the fenced area. The beam should be positioned to monitor the entire length of the fence on the side with the gate. The alarm zone shall be monitored at the central alarm desk (as part of the intrusion detection system) by remote monitoring of the same type as the intrusion detection system. One zone and an infrared beam detection system shall be provided for each location where there is a gate in the fenced-in area of the site.

16.15.3.5 CLOSED-CIRCUIT TELEVISION SECURITY SYSTEMS

A complete closed-circuit television (CCTV) security system shall be designed. The professional designing this system shall have at least 2 to 3 years of experience in the design of similar installations. Conduit and wiring shall be installed for the system and a camera shall be installed at all entrance and exit areas. The location of the camera shall be suitable for monitoring persons' movements when they are entering or leaving the building. An emergency circuit shall provide power for each camera location. Conduit, wiring, cameras, and all other appropriate monitoring equipment shall also be installed in all parking lots, loading docks, and computer areas.

16.15.3.5.1 CAMERAS, FIXED OR PAN-TILT-ZOOM

Cameras shall be of the fixed or pan-tilt-zoom type, as required for each specific location. Cameras shall be housed in proper enclosures for the environment in which they are to operate (e.g., enclosures with defrosters or heaters, weatherproof enclosures, corrosion-resistant or vandal-proof enclosures).

16.15.3.5.2 CAMERAS, MONITORED AND CONTROLLED

All cameras shall be monitored and controlled at the facility's central control station. Monitors shall be event driven. A video cassette recorder (VCR) shall be provided to record unauthorized access (control by guard). A 120-volt single-duplex receptacle (emergency power) shall be provided immediately next to all CCTV camera locations.

16.15.3.5.3 CCTV SECURITY CAMERAS, LOADING DOCKS

CCTV cameras shall be provided to monitor entry and exit from the loading dock areas. CCTV monitors (in addition to that at the central console for the loading dock areas) shall be provided in the loading dock office to provide identification of delivery vehicles before the loading dock doors are opened.

16.15.3.6 PERIMETER SYSTEMS

A complete grade-level perimeter intrusion detection system shall be designed. This system shall be in addition to the intrusion detection system described above and shall be monitored at the same control panel provided for the intrusion detection system.

16.15.3.6.1 ULTRASONIC PROTECTION

Ultrasonic protection should be furnished to protect the grade-level, glass-enclosed office area and any other area that contains exterior glass at grade level. The ultrasonic control panel shall be the type that controls nominally 20 pairs of transmitters and receivers. Input should be connected into the main alarm panels as a separate zone. Sufficient transmitter-receiver pairs shall be installed to protect the entire office area and other grade level areas with exterior glass.

16.15.3.7 DATA PROCESSING

A complete access-intrusion detection system shall be designed for all data processing areas. A card reader and balanced magnetic switch shall be provided at each door leading into the data processing areas. Card readers shall be of the proximity type. The system shall be monitored at the central control station for the facility. The control computer shall be capable of programming access cards by hour and day. The central controller shall also furnish a printout of time, date, card number, etc., for the person entering or leaving the data processing area. The system shall be of the anti-passback type.

16.15.3.7.1 COMPUTER AREA DOORS

If a card access system is being furnished for other doors in the facility, the same cards shall work for the computer area doors (if so encoded for certain personnel).

16.15.3.7.2 CENTRAL CONTROL DOOR MONITORING

The door shall be monitored at the central control station in case it is left open or the card access system is bypassed.

16.15.3.8

The parking facility(s) shall be enclosed and equipped with a perimeter sensor system and lockable gates. The gates shall be equipped with a computerized access control system. EPA card readers shall be installed in parallel with any other card readers (if required) on all the access roads.

ACCESS SYSTEM

The

For very small facilities, a programmable keypad may be used in lieu of a card reader. The same

16.15.4 DISASTER EVACUATION SYSTEM

the facility is located in an area prone to tornados or hurricanes, a warning/evacuation alarm system for the facility's emergency preparedness plan, which shall be coordinated with the community's emergency

16.15.5 EXIT LIGHTING AND MARKINGS

- Exit
29 CFR §1910.36 and §1910.37 and the Life Safety Code (NFPA 101). The means of egress, exterior

- Internally illuminated signs shall meet the following criteria:

Emergency lighting for the area shall conform to OSHA and the Life Safety Code and shall provide

- Exit signs shall be at least 8 inches high by 12½ inches long.

Letters shall be at least 6 inches high.

- maximum physical distance to a visual sign shall not exceed 100 feet. In addition, an exit sign shall be visible from all points in the corridor.

Appendix A - Codes, Regulatory Requirements, Reference Standards, Trade Organizations, and Guides

For all documents listed in this appendix, the latest edition shall be used unless indicated otherwise by the EPA contracting officer. (Where an acronym may stand for more than one name, use in this document shall be as indicated in the specific Section.)

AA	Aluminum Association 900 19th St., NW Washington, DC 20006	ABMA	American Boiler Manufacturers Association 950 North Glebe Rd. Suite 160 Arlington, VA 22203
AAA	American Arbitration Association 140 W. 51st. St. New York, NY 10020	ACCA	Air-Conditioning Contractors of America 1513 16th St. Washington, DC 20036
AABC	Associated Air Balance Council 1518 K St., NW Washington, DC 20005	ACEA	Allied Construction Employers Association 180 N. Executive Drive Brookfield, WI 53008
AAMA	Architectural Aluminum Manufacturers Association 2700 River Rd., Suite 118 Des Plaines, IL 60018	ACEC	American Consulting Engineers Council 1015 15th St., NW, Suite 802 Washington, DC 20005
AASHTO	American Association of State Highway and Transportation Officials 444 N. Capitol St., NW, Suite 225 Washington, DC 20001	ACGIH	American Conference of Government Industrial Hygienists 6500 Glenway Ave., Building D-7 Cincinnati, OH 45211
ABC	Associated Builders and Contractors, Inc. 729 15th St., NW Washington, DC 20005 <i>or</i> Association of Bituminous Contractors 2020 K St., NW, Suite 800 Washington, DC 20006	ACI	American Concrete Institute 22400 W. Seven Mile Rd. Detroit, MI 48219
ABCA	American Building Contractors Association 11100 Valley Blvd., Suite 120 El Monte, CA 91731	ACPA	American Concrete Pavement Association 3800 N. Wilke Rd., Suite 490 Arlington Heights, IL 60004
		ACPA	American Concrete Pipe Association 8320 Old Courthouse Rd. Vienna, VA 22180 <i>or</i>

	American Concrete Pumping Association P.O. Box 4307 1034 Tennessee St. Vallejo, CA 94590	AHA	American Hardboard Association 520 N. Hicks Rd. Palantine, IL 60067
ACSM	American Congress on Surveying and Mapping 210 Little Falls St. Falls Church, VA 22046	AHLI	American Home Lighting Institute 435 N. Michigan Ave., Suite 1717 Chicago, IL 60611
ADA	Americans with Disabilities Act <i>(For employment questions)</i> U.S. Equal Employment Opportunity Commission ADA Legal Services 1801 L St., NW Washington, DC 20507 <i>(For transportation questions)</i> U.S. Department of Transportation Office of Assistant General Counsel for Regulation and Enforcement 400 7th St., SW Washington, DC 20590 <i>(For public accommodations questions)</i> U.S. Department of Justice Office of Americans with Disabilities Act P. O. Box 66118 Washington, DC 20035-6118 <i>(For telecommunications questions)</i> Federal Communications Commission Consumer Assistance 1919 M St., NW Washington, DC 20554 <i>(For architectural accessibility questions)</i> Access Board 1331 F St., NW, Suite 1000 Washington, DC 20004-1111	AHMA	American Hardware Manufacturers Association 931 N. Plum Grove Rd. Schaumburg, IL 60173
		AI	Asphalt Institute Asphalt Institute Building College Park, MD 20740
		AIA	American Institute of Architects 1735 New York Ave., NW Washington, DC 20006
		AIA / NA	Asbestos Information Association/ North America 1745 Jefferson Davis Hwy., Suite 509 Arlington, VA 22202
		AIC	American Institute of Constructors 20 S. Front St. Columbus, OH 43215
		AISC	American Institute of Steel Construction, Inc. 400 N. Michigan Ave. Chicago, IL 60611
		AISI	American Iron and Steel Institute 1133 15th St., NW, Suite 300 Washington, DC 20005
		AITC	American Institute of Timber Construction 11818 S.E. Mill Plain Blvd. Vancouver, WA 98684
AGA	American Gas Association, Inc. 1515 Wilson Blvd. Arlington, VA 22209	ALSC	American Lumber Standards Committee P.O. Box 210 Germantown, MD 20874
AGC	Associated General Contractors of America 1957 East St., NW Washington, DC 20006	AMCA	Air Movement and Control Association 30 West University Dr. Arlington Heights, IL 60004

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ANL	Argonne National Laboratory 9800 South Cass Ave. Argonne, IL 60439	<i>or</i>	
ANS	American Nuclear Society 555 North Kensington Ave. LaGrange Park, IL 60525		American Subcontractors Association 1004 Duke St. Alexandria, VA 22314
ANSI	American National Standards Institute 1430 Broadway New York, NY 10018	ASC	Adhesive and Sealant Council, Inc. 1500 Wilson Blvd., Suite 515 Arlington, VA 22209-2495
APA	American Plywood Association P.O. Box 11700 Tacoma, WA 98411		<i>or</i>
APA	Architectural Precast Association 825 E. 64th St. Indianapolis, IN 46220		Associated Specialty Contractors 7315 Wisconsin Ave. Bethesda, MD 20814
APFA	American Pipe Fitting Association 8136 Old Keene Mill Rd., #B-311 Springfield, VA 22152	ASCC	American Society of Concrete Construction 426 S. Westgate Addison, IL 60101
API	American Petroleum Institute 1220 L. St., NW Washington, DC 20037	ASCE	American Society of Civil Engineers 345 E. 47th St. New York, NY 10017
AREA	American Railway Engineering Association 50 F St., NW, Suite 7702 Washington, DC 20001	ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. 1791 Tulie Circle, NE Atlanta, GA 30329
ARI	Air-Conditioning and Refrigeration Institute 1501 Wilson Blvd., 6th Floor Arlington, VA 22209	ASID	American Society of Interior Designers 1430 Broadway New York, NY 10018
ARMA	Asphalt Roofing Manufacturers Association 6288 Montrose Road Rockville, MD 20852	ASME	American Society of Mechanical Engineers United Engineering Center 345 E. 47th St. New York, NY 10017
ARTBA	American Road and Transportation Builders Association 525 School St., SW Washington, DC 20024	ASPE	American Society of Professional Estimators 3617 Thousand Oaks Blvd., Suite 210 Westlake, CA 91362
ASA	Acoustical Society of America 500 Sunnyside Blvd. Woodbury, NY 11797	ASSE	American Society of Sanitary Engineers P.O. Box 40362 Bay Village, OH 44140

ASTM	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103	CA	Congressional Acts Superintendent of Documents Government Printing Office Washington, DC 20402
AWCI	Association of the Wall and Ceiling Industries International 25 K St., NE, Suite 300 Washington, DC 20002	CABO	Council of American Building Officials 5203 Leesburg Pike, Suite 708 Falls, Church, VA 22041
AWI	Architectural Woodwork Institute 2310 S. Walter Reed Dr. Arlington, VA 22206	CDA	Copper Development Association, Inc. Greenwich Office Park 2 51 Weaver St. Grant, CT 06836
AWS	American Welding Society, Inc. 550 N.W. LeJeune Rd. Miami, FL 33126	CERC	Coastal Engineering Research Center U.S. Army Corps of Engineers P.O. Box 631 Vicksburg, MA 39180
AWWA	American Water Works Association 6666 West Quincy Ave. Denver, CO 80235	CFR	Code of Federal Regulations Superintendent of Documents Government Printing Office Washington, DC 20402
BHMA	Builder's Hardware Manufacturers Association, Inc. 60 E. 42nd St., Room 511 New York, NY 10165	CGA	Compressed Gas Association Crystal Gateway One, Suite 501 1235 Jefferson Davis Highway Arlington, VA 22202
BIA	Brick Institute of America 11490 Commerce Park Dr., Suite 300 Reston, VA 22091	CIEA	Construction Industry Employers Association 625 Ensminger Rd. Tonawanda, NY 14150
BMRI	Building Materials Research Institute, Inc. 501 5th Ave., #1402 New York, NY 10017	CIMA	Construction Industry Manufacturers Association 111 E. Wisconsin Ave., Suite 940 Milwaukee, WI 53202-4879
BOCA	Building Officials and Code Administrators International 4051 W. Flossmoor Rd. Country Club Hills, IL 60477	CISCA	Ceilings and Interior Systems Construction Association 104 Wilmot, Suite 201 Deerfield, IL 60015
BRB	Building Research Board 2101 Constitution Ave., NW Washington, DC 20418	CISPI	Cast Iron Soil Pipe Institute 1499 Chain Bridge Rd., Suite 203 McLean, VA 22101
BSC	Building Systems Council 15th and M Sts., NW Washington, DC 20005		
BSI	Building Stone Institute 420 Lexington Ave., Suite 2800 New York, NY 10170		

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CLFMI	Chain Link Fence Manufacturers Institute 1776 Massachusetts Ave., NW Suite 500 Washington, DC 20036	DIPRA	Ductile Iron Pipe Research Association 245 Riverchase Parkway E., Suite 0 Birmingham, AL 35244
CMAA	Crane Manufacturers Association of America 1326 Freeport Road Pittsburgh, PA 15238	DOE	U.S. Department of Energy 1000 Independence Ave., SW Washington, DC 20585
CPMA	Construction Products Manufacturing Council P.O. Box 21008 Washington, DC 20009-0508	DOE/OSTI	DOE/Office of Scientific and Technical Information P.O. Box 62 Oak Ridge, TN 37831
CRA	California Redwood Association 405 Enfrente Dr., Suite 200 Nevato, CA 94949	DOT	U.S. Department of Transportation 400 7th St., SW Washington, DC 20590
CRI	Carpet and Rug Institute P.O. Box 2048 Dalton, GA 30722-2048	EIA	Electronics Industries Association 2001 Eye St., NW Washington, DC 20006
CRSI	Concrete Reinforced Steel Institutes 933 N. Plum Grove Rd. Schaumburg, IL 60195	EIMA	Exterior Insulation Manufacturers Association Box 75037 Washington, DC 20013
CSI	Construction Specifications Institute 601 Madison St. Alexandria, VA 22314	EO	Executive Orders National Archives and Records Administration 8th St. and Pennsylvania Ave., NW Washington, DC 20408
CTI	Ceramic Tile Institute 700 N. Virgil Ave. Los Angeles, CA 90029	EPA	Environmental Protection Agency 401 M St., SW Washington, DC 20460
	<i>or</i>	ESCSI	Expanded Shale, Clay and Slate Institute 6218 Montrose Rd. Rockville, MD 20852
DFI	Deep Foundations Institute P.O. Box 359 Springfield, NJ 07081	FAA	Federal Aviation Administration U.S. Department of Transportation 400 7th St., SW Washington, DC 20590
DHI	Door and Hardware Institute 7711 Old Springhouse Rd. McLean, VA 22101-3474	FCC	Federal Construction Council Building Research Board National Research Council 2101 Constitution Ave., NW Washington, DC 20418

FEMA	Federal Emergency Management Agency Federal Center Plaza 500 C St., SW Washington, DC 20472	GBCA	General Building Contractors Association 36 S. 18th St. P.O. Box 15959 Philadelphia, PA 19103
FGMA	Flat Glass Marketing Association White Lakes Professional Building 3310 Harrison St. Topeka, KS 66611	GSA	General Services Administration Public Buildings Service Office of Governmentwide Real Property Policy and Oversight 19th and F Sts., NW Washington, DC 20405
FHA	Federal Housing Administration 451 7th St., SW, Rm. 3158 Washington, DC 20410	HES	Health Education Services P.O. Box 7282 Albany, NY 12224
FIPS	Federal Information Processing Standards National Bureau of Standards Room 64-B, Technology Gaithersburg, MD 20899	HPMA	Hardwood Plywood Manufacturers Association P.O. Box 2789 Reston, VA 22090
FM	Factory Mutual Engineering and Research 1151 Boston Providence Turnpike Norwood, MA 02062		International Association of Bridge, Structural and Ornamental Iron Workers 1750 New York Ave., NW, Suite 400 Washington, DC 20006
FPRS	Forest Products Research Society 2801 Marshall Ct. Madison, WI 53705	IAEA	International Atomic Energy Agency Vienna International Center Wagranerstrasse 5 Post Fach 100 A-1400 Vienna, Austria
FR	Federal Register Superintendent of Documents U.S. Government Printing Office 710 North Capitol St., NW Washington, DC 20402	IALD	International Association of Lighting Designers 18 E. 16th St., Suite 208 New York, NY 10003
FS	Federal Specifications Attention: NPFC Code 1052 Naval Publications and Forms Center 5801 Tabor Ave. Philadelphia, PA 19120-5099	IAPMO	International Association of Plumbing and Mechanical Officials 20001 Walnut Drive S. Walnut, CA 91789
FTI	Facing Tile Institute P.O. Box 8880 Canton, OH 44711	ICAA	Insulation Contractors Association of America 15819 Crabbs Branch Way Rockville, MD 20855
GA	Gypsum Association 1603 Orrington Ave., Suite 1210 Evanston, IL 60201	ICBO	International Conference of Building Officials 5360 S. Workman Mill Rd. Whittier, CA 90601

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ICEA	Insulated Cable Engineers Association P. O. Box P South Yarmouth, MA 02664	IRF	International Road Federation 525 School St., SW Washington, DC 20024
ICRP	International Commission on Radiological Protection Maxwell House Fairview Park Elmsford, NY 10523	ISDSI	Insulated Steel Door Systems Institute 712 Lakewood Center North 14600 Detroit Ave. Cleveland, OH 44107
IEEE	Institute of Electrical and Electronics Engineers 345 E. 47th St. New York, NY 10017	LANL	Los Alamos National Laboratory P.O. Box 1663 Los Alamos, NM 87545
IES	Institute of Environmental Sciences 940 East Northwest Highway Mount Prospect, IL 56056	LBL	Lawrence Berkeley Laboratory 1 Cyclostron Road Berkeley, CA 94720
IESNA	Illuminating Engineering Society of North America 345 E. 47th St. New York, NY 10017	LLNL	Lawrence Livermore National Laboratory Livermore, CA 94550
IFI	Industrial Fasteners Institute 1505 E. Ohio Building Cleveland, OH 44114	LPI	Lightning Protection Institute 48 North Ayer St. Harvard, IL 60033
IHEA	Industrial Heating Equipment Association 1901 N. Moore St. Arlington, VA 22209		Manufacturers Standardization Society of the Valve and Fittings Industry 127 Park St., NE Vienna, VA 22180
IILP	International Institute of Lath and Plaster 795 Raymond Ave. St. Paul, MN 55114	MBMA	Metal Building Manufacturers Association 1230 Keith Building Cleveland, OH 44115
ILIA	Indiana Limestone Institute of America Stone City Bank Building, Suite 400 Bedford, IN 47421	MCAA	Mason Contractors Association of America 17W 601 14th St. Oakbrook Terrace, IL 60181
IMI	International Masonry Institute 823 15th St., NW, Suite 1001 Washington, DC 20005		<i>or</i>
IPCEA	Insulated Power Cable Engineers Association		Mechanical Contractors Association of America 5410 Grosvenor, Suite 120 Bethesda, MD 20814
		MIA	Marble Institute of America 33505 State St. Farmington, MI 48024

MFMA	Maple Flooring Manufacturers Association 60 Revere Dr., Suite 500 Northbrook, IL 60062	NADC	National Association of Dredging Contractors 1625 I St., NW, Suite 321 Washington, DC 20006
MLSFA	Metal Lath/Steel Framing Association 600 S. Federal, Suite 400 Chicago, IL 60605	NAEC	National Association of Elevator Contractors 4053 LaVista Rd., Suite 120 Tucker, GA 30084
	National Building Material Distributors Association 1701 Lake Ave., Suite 170 Glenview, IL 60025	NAFCD	National Association of Floor Covering Distributors 13-126 Merchandise Mart Chicago, IL 60654
	National Forest Products Association 1250 Connecticut Ave., NW, Suite 200 Washington, DC 20036	NAHB	National Association of Home Builders 15th and M Sts., NW Washington, DC 20005
	National Housing Rehabilitation Association 1726 18th St., NW Washington, DC 20009	NAHRO	National Association of Housing Redevelopment Officials 1320 187th St., NW Washington, DC 20036
	National Particleboard Association 2306 Perkins Pl. Silver Spring, MD 20910	NAPA	National Asphalt Pavement Association 6811 Kenilworth Ave., Suite 620 P.O. Box 517 Riverdale, MD 20737
	National Wood Window and Door Association 205 Touhy Ave. Park Ridge, IL 60068	NAPHCC	National Association of Plumbing, Heating, and Cooling Contractors P.O. Box 6808 Falls Church, VA 22046
NAAMM	National Association of Architectural Metal Manufacturers 600 South Federal St. Chicago, IL 60605	NARSC	National Association of Reinforcing Steel Contractors 10382 Main St. P.O. Box 225 Fairfax, VA 22030
NACE	National Association of Corrosion Engineers P.O. Box 218340 Houston, TX 77218	NASA	National Aeronautics and Space Administration 300 East St., SW Washington, DC 20546
NADC	National Association of Demolition Contractors 4415 W. Harrison St. Hillside, IL 60162	NAVFAC	U.S. Naval Facilities Engineering Command Attention Cash Sales/Code 1051 Naval Publications and Forms Center 5801 Tabor Ave. Philadelphia, PA 19120-5099
	<i>or</i>		

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NAWIC	National Association of Women in Construction 327 S. Adams St. Fort Worth, TX 76104	NESC	National Electrical Safety Code Institute of Electrical & Electronics Engineers, Inc. 345 East 47th St. New York, NY 10017
NBMA	National Building Manufacturers Association 142 Lexington Ave. New York, NY 10016	NFPA	National Fire Protection Association Batterymarch Park Quincy, MA 02269
NBS	National Bureau of Standards (currently National Institute of Standards and Technology) Gaithersburg, MD	NGA	National Glass Association 8200 Greensboro Dr., Suite 302 McLean, VA 22101
NCA	National Constructors Association 1101 15th St., NW, Suite 1000 Washington, DC 20005	NIH	National Institutes of Health Public Health Service U.S. Department of Health and Human Services Bethesda, MD 20205
NCMA	National Concrete Masonry Association P.O. Box 781 Herndon, VA 22070	NIJ	National Institute of Justice 633 Indiana Ave., NW Washington, DC 20531
NCRP	National Council on Radiation Protection and Measurement 7910 Woodmont Ave., Suite 800 Bethesda, MD 20814	NIOSH	National Institute of Occupational Safety and Health U.S. Public Health Service
NCSBCS	National Conference of State Building Codes and Standards 481 Carlisle Dr. Herndon, VA 22070	NKCA	National Kitchen Cabinet Association P.O. Box 6830 Falls Church, VA 22046
NEC	National Electrical Code National Fire Protection Association Batterymarch Park Quincy, MA 02269	NLA	National Lime Association 3601 N. Fairfax Dr. Arlington, VA 22201
NECA	National Electrical Contractors Association 7315 Wisconsin Ave. 13th Floor, West Building Bethesda, MD 20814	NLBMDA	National Lumber and Building Material Dealers Association 40 Ivy St., SE Washington, DC 20003
NEMA	National Electrical Manufacturers Association 2101 L St., NW, Suite 300 Washington, DC 20037	NOAA	National Oceanic and Atmospheric Administration Washington Science Center, Building 5 6010 Executive Blvd. Rockville, MD 20852
		NOFMA	National Oak Flooring Manufacturers Association P.O. Box 3009 Memphis, TN 38173-0009

NPCA	National Paint and Coatings Association 1500 Rhode Island Ave., NW Washington, DC 20005	NTIA	National Telecommunications and Information Administration Main Commerce Building Washington, DC 20230
NPCA	National Precast Concrete Association 825 E. 64th St. Indianapolis, IN 46220	NTIS	National Technical Information Service 5485 Port Royal Rd. Springfield, VA 22161
NRC	U.S. Nuclear Regulatory Commission Publications Division Washington, DC 20555	NTMA	National Terrazzo and Mosaic Association 3166 Des Plaines Ave., Suite 132 Des Plaines, IL 60018
NRCA	National Roofing Contractors Association 1 O'Hare Center 6250 River Rd. Rosemont, IL 60018	NWMA	National Woodwork Manufacturers' Association 400 W. Madison St. Chicago, IL 60606
NRMCA	National Ready Mixed Concrete Association 900 Spring St. Silver Spring, MD 20910	NWWDA	National Wood Window and Door Association 1400 East Touhy Ave. Des Plaines, IL 60018
NSA	National Security Agency/ Central Security Service Fort Meade, MD 20755	OMB	Office of Management and Budget Old Executive Office Building Washington, DC 20503
	<i>or</i>	OPCMIA	Operative Plasterers' and Cement Masons' International Association of the United States and Canada 1125 17th St., NW, 6th Floor Washington, DC 20036
NSF	National Sanitation Foundation P.O. Box 1468 34 Plymouth Rd. Ann Arbor, MI 48015	OSHA	Occupational Safety and Health Administration U.S. Department of Labor 200 Constitution Ave., NW Washington, DC 20201
NSPC	National Standard Plumbing Code Published by: National Association of Plumbing-Heating-Cooling Contractors P.O. Box 6808 Falls Church, VA 22040		Pipe Line Contractors Association 4100 First City Center 1700 Pacific Ave. Dallas, TX 75201
NSPE	National Society of Professional Engineers 1420 King St. Alexandria, VA 22314	PCA	Portland Cement Association 5420 Old Orchard Rd. Skokie, IL 60077
		PCI	Precast Concrete Institute 175 W. Jackson Blvd., Suite 1859 Chicago, IL 60604

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PDCA	Painting and Decorating Contractors of America 7223 Lee Highway Falls Church, VA 22046		Scientific Apparatus Makers Association 225 Reinekers Lane Suite 625 Alexandria, VA 22314
PDI	Plumbing and Drainage Institute 1106 W. 77th St. Dr. Indianapolis, IN 46260	SBA	Systems Builders Association P.O. Box 117 West Milton, OH 45383
PHCIB	Plumbing-Heating-Cooling Information Bureau 303 E. Wacker Dr., Suite 711 Chicago, IL 60601	SBCCI	Southern Building Code Congress International, Inc. 900 Montclair Rd. Birmingham, AL 35213
PMI	Plumbing Manufacturers Institute 800 Roosevelt Rd., Building C, Suite 20 Glen Ellyn, IL 60137	SCS	Soil Conservation Service U.S. Department of Agriculture 14th St. and Independence Ave., SW Washington, DC 20250
PPI	Plastics Pipe Institute 355 Lexington Ave. New York, NY 10017	SDI	Steel Deck Institute P.O. Box 9506 Canton, OH 44711
PSIC	Passive Solar Industries Council 2836 Duke St. Alexandria, VA 22314		<i>or</i>
PTI	Post-Tensioning Institute 1717 W. Northern Ave., Suite 218 Phoenix, AZ 85021		Steel Door Institute 712 Lakewood Center N. 14600 Detroit Ave. Cleveland, OH 44107
RCRC	Reinforced Concrete Research Council 5420 Old Orchard Rd. Skokie, IL 60077	SIGMA	Sealed Insulating Glass Manufacturers Association 111 E. Wacker Dr., Suite 600 Chicago, IL 60601
RCSHSB	Red Cedar Shingle and Handsplit Shake Bureau 515 116th Ave., NE, Suite 275 Bellevue, WA 98004	SJI	Steel Joist Institute 1205 48th Ave., N., Suite A Myrtle Beach, SC 29577
RFCA	Resilient Flooring and Carpet Association, Inc. 14570 E. 14th St., Suite 511 San Leandro, CA 94570	SMA	Screen Manufacturers Association 655 Irving Park, Suite 201 Chicago, IL 60613-3198
			<i>or</i>
RFCI	Resilient Floor Covering Institute 966 Hungerford Dr., Suite 12B Rockville, MD 20850		Stucco Manufacturers Association 14006 Ventura Blvd. Sherman Oaks, CA 91423

SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc. 8224 Old Courthouse Rd. Vienna, VA 22180	TIMA	Thermal Insulation Manufacturers Association 7 Kirby Plaza Mount Kisco, NY 10549
SMWIA	Sheet Metal Workers International Association 1750 New York Ave., NW Washington, DC 20006		U.S. Department of Labor/ Occupational Safety and Health Administration 200 Constitution Ave., NW Washington, DC 20210
SNL	Sandia National Laboratories P.O. Box 5800 Albuquerque, NM 87185		U.S. Forest Products Laboratory One Gifford Pinchot Dr. Madison, WI 53705-2398
SPRI	Single Ply Roofing Institute 104 Wilmot Road, Suite 201 Deerfield, IL 60015-5195	UBC	Uniform Building Code International Conference of Building Officials 5360 Workman Mill Road Whittier, CA 90601-2298
SSFI	Scaffolding, Shoring, and Forming Institute, Inc. 1230 Keith Building Cleveland, OH 44115	UL	Underwriters Laboratories Inc. 333 Pfingsten Rd. Northbrook, IL 60062
SSPC	Steel Structures Painting Council 4400 5th Ave. Pittsburgh, PA 15213	USACE	U.S. Department of the Army Corps of Engineers 20 Massachusetts Ave., NW Washington, DC 20314
SWI	Sealant and Waterproofers Institute 3101 Broadway, Suite 300 Kansas City, MO 64111 <i>or</i> Steel Window Institute 1230 Keith Building Cleveland, OH 44115	USAF	U.S. Department of the Air Force Manuals may be ordered from headquarters of any Air Force Base
TCA	Tile Council of America P.O. Box 2222 Princeton, NJ 08542 <i>or</i>	VMA	Valve Manufacturers Association of America 1050 17th St., NW, Suite 701 Washington, DC 20036
TCA	Tilt-Up Concrete Association 5420 Old Orchard Rd. Skokie, IL 60077	WMA	Wallcovering Manufacturers Association 355 Lexington Ave. New York, NY 10017
TCAA	Tile Contractors Association of America, Inc. 112 N. Alfred St. Alexandria, VA 22314	WPCF	Water Pollution Control Federation 601 Wythe St. Alexandria, VA 22314-1994
		WRC	Water Resources Council, Hydrology Committee U.S. Department of the Interior C St. between 18th & 19th Sts., NW Washington, DC 20240

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WRI **Wire Reinforcement Institute**
8361-A Greensboro Dr.
McLean, VA 22102

WWPA **Western Wood Products Association**
Yeon Building
522 S.W. 5th Ave.
Portland, OR 97204

END OF APPENDIX A

Appendix B - Indoor Air Quality (IAQ) Requirements

B.1 Design Process

The Indoor Air Quality Requirements are organized to correspond to the design and construction process. This section addresses the design process.

B.1.1 GENERAL

A new facility using good building practices in indoor air quality design and operation is required. It is also the intent that IAQ be achieved without sacrificing other important aspects of the facility. A facility is required in which indoor air quality is maintained at the best practicable level using currently available knowledge and proven technology that is cost effective and consistent with the normal function of a laboratory facility with related office space. As a result, a Quality Assurance/Quality Control Manual shall be produced. The Indoor Air Quality Control Plan referenced throughout this document shall be contained in this Manual. The IAQ Plan shall address in detail building materials selection, minimizing introduction of outdoor air pollution, pre-occupancy procedures to accelerate off-gassing, and operations and maintenance procedures that limit introduction of harmful chemicals. A number of considerations are presented here to emphasize the significance in achieving acceptable indoor air quality. These considerations are followed by primary strategies for IAQ control. They are listed below and discussed in more detail at various points throughout this section.

B.1.1.1 CONSIDERATIONS FOR ACCEPTABLE INDOOR AIR QUALITY.

Refer to the publication, *Building Air Quality: A Guide for Building Owners and Facility Managers*. U.S. Department of Health and Human Services (DHHS), Center for Disease Control (CDC), National Institute of Occupational Safety and Health (NIOSH) Pub. No. 91-114.

- B.1.1.1.1 The most effective means of indoor air pollution control is to eliminate, reduce, or contain the sources of indoor air pollution. Evidence must be provided that this strategy has been applied to every aspect of the building design, construction requirements, and operational requirements. The overall strategy must include control strategies for outdoor sources, building materials and equipment, furnishings, occupants, and maintenance, including housekeeping activities that occur indoors.
- B.1.1.1.1.1 Training of operations and maintenance personnel, as well as occupants, in heating, ventilation, and air-conditioning (HVAC) operations is a requirement.
- B.1.1.1.1.2 Proper operation and maintenance of the facilities and their HVAC systems are critical to maintaining IAQ. Training of operations and maintenance personnel is a requirement. Explicit assumptions regarding operation and maintenance must be made during design and must be documented in a facilities operation manual. They must reflect a clear intent to maintain indoor air quality at the highest practicable level.
- B.1.1.1.1.3 Required ventilation air must be delivered to occupants' "breathing zone." This requires careful attention to the design and installation of the air distribution system and its controls, particularly at the local level. Innovative approaches to achieving improved "ventilation efficiency" are sought in order to minimize wasteful and ineffective space air distribution. A clear presentation of the ventilation system space air distribution concept is a part of the design professional's responsibilities. (For definition of "breathing zone" and "ventilation efficiency" see B.2 - Supplemental Indoor Air Quality Information.)

- B.1.1.1.1.4 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, is to be considered a part of these requirements.

B.1.1.2 PRIMARY STRATEGIES FOR IAQ CONTROL

Primary strategies are as follows:

- Source control
- Ventilation controls
 - Outside air supply
 - Air cleaning
 - Space air distribution
- Operation and maintenance.

B.1.2 SOURCE CONTROL

While it shall be required that all of the above-listed strategies be employed to control IAQ, source control is considered the most effective control method for most pollutants. Effective source control requires that potential sources be clearly identified and addressed. It must be demonstrated that the design involved thorough consideration of sources of indoor pollutants and their control. The discussion on source control is organized to cover outdoor sources and indoor sources of indoor air pollutants. Potential pollutant sources shall be examined at each stage of the building design and development process and effective control strategies shall be utilized.

B.1.2.1 OUTDOOR POLLUTANT SOURCES

- B.1.2.1.1 The sources of air pollutants that must be considered are adjacent and nearby stationary pollution sources, for example, exhausts from other research facilities or from commercial buildings such as dry-cleaning establishments or restaurants, nearby roadways, parking lots, loading docks, trash storage, and garage and their motor vehicle traffic patterns. Consideration must be given to variations in the potential sources over time, including daily, weekly, and seasonal patterns.
- B.1.2.1.2 Temporal and spatial variations in wind direction and velocity, traffic patterns, and emissions from industrial processes that affect air quality at the site must be considered. The locations and forms of adjacent buildings that might result in local wind patterns causing reentrainment of the facility's own exhausts must be considered and addressed. The potential impact that ponds, cooling towers, cooling coil drip pans, and other potential sites of microbial contamination may have on IAQ must also be considered. Previous land uses, such as agriculture or industry, might result in emissions from contaminated soil or groundwater as a potential source of indoor air pollutants. Some examples of potentially significant prior uses are wood preservation and treatment; solid or hazardous waste handling, storage, treatment, or disposal; dry-cleaning processes; leather, paint, or chemical manufacturing; refrigerated storage; gasoline storage or dispensing; and agriculture. Even nearby building demolition can result in significant site contamination through release of building materials such as asbestos into air or into soil, which may remain on-site or be backfilled onto it.
- B.1.2.1.3 **SITE EVALUATION**
- B.1.2.1.3.1 Solutions must include the potential impact of the site itself on indoor air quality. The prior history of the site must be disclosed as part of the research and review process (see the Supplemental Indoor Air Quality Information, Site Evaluation, and Contaminants Source Distribution subsections later in this appendix). Solutions must include consideration of the following factors:

- Prior history of the site

Appendix B - Indoor Air Quality Requirements

- Off-site and on-site sources of pollution
- Soils and soil gases (including radon, organic chemicals, metals, and microbes)
- Ambient air quality
- Landscaping (including highly sporulating types of plantings).

B.1.2.1.3.2 The design professional shall review his responsibilities for an Environmental Assessment (EA) and an Environmental Impact Study (EIS) as described in Section 2, Site Work, of this Manual (subsection 2.3.1). Also see Chapter 7, paragraph 9, of the *Safety Manual* for additional requirements.

B.1.2.1.4 **EXTERIOR DESIGN IMPLICATIONS**
Solutions must include the following considerations:

- B.1.2.1.4.1 If this project is a new facility, locate the building on the site as far removed as possible from pollutant sources, or out of the normal wind patterns coming from pollutant sources. Vegetation or other screens should be utilized to form a barrier to particulate matter or to absorb certain chemicals. Vegetation should be used, where effective, to protect a building from motor vehicle pollutant sources. Where vegetation is used, potential microbial contamination from it should be avoided.
- B.1.2.1.4.2 Building designs must include locating air intakes remote from pollution generation points or areas, creating architectural barriers to direct polluted airflow away from building air intakes, providing appropriate filtration for identified pollutants, and locating air-pollutant-sensitive elements away from exterior sources. Air intake locations for both mechanical and natural ventilation shall not be located near exhaust outlets or where outdoor air pollution plumes are expected.
- B.1.2.1.4.3 Selection and location of window and door systems must include consideration of their designed protection against infiltration and the outdoor air pollutants that might pass through the openings.
- B.1.2.1.4.4 The chemical and physical interactions between the building fabric and identified pollutants that might cause deterioration of the building fabric and systems or that might result in amplification of the contaminant concentrations in indoor air must be addressed.

B.1.2.2 INDOOR POLLUTANT SOURCES

B.1.2.2.1 Indoor sources include the building fabric itself, equipment, furnishings, appliances, human metabolism and activities, consumer products, maintenance materials and processes, pest control materials, and others.

B.1.2.2.2 INTERIOR DESIGN APPLICATIONS

B.1.2.2.2.1 Major approaches to source control for indoor pollutants include building design, careful material selection, materials modification and treatment; isolation of pollution-generating activities; and management controls on polluting activities.

B.1.2.2.2.2 Source reduction involves a variety of design strategies and practices, including the following:

- Source removal
- Product selections
- Substitution
- Product use controls

- Enclosure
- Encapsulation
- Treatment
- Conditioning.

B.1.2.2.2.3 The building design must reflect consideration of the IAQ impacts of siting, orientation, configuration, materials, environmental control, and interior layout. The basic characteristics of the building—its size, shape, and exterior shell, as well as major environmental control strategies, including illumination, ventilation, acoustics, and thermal environment—must reflect the emphasis placed on IAQ. This requires that the preliminary estimates of loads and the capacities of systems designed to handle them include specific loads related to ventilation requirements and air cleaning (filtration, precipitators, absorption, or scrubbing, as required by ambient air and indoor air quality standards referenced in this section and applicable codes and standards).

B.1.2.2.2.4 Ideally, precipitators, absorbers, and scrubbers should be avoided because of their high maintenance costs. Where proposed, a cost/benefit study must be submitted.

B.1.2.3 BUILDING MATERIALS EVALUATION

The design professional shall provide descriptions of measures that will be taken to minimize the use of indoor air pollution sources in the building construction, finishes, maintenance, and operation. Measures consist of the following four phases.

- B.1.2.3.1 It shall be the responsibility of the design professional to review all products and materials and identify those considered likely to emit toxic or irritating chemicals in the completed facility. The design professional shall establish a library or repository that is locally available for inspection and use by the Government. This library shall contain product composition specifications for all products and materials used in construction. Copies of all specifications shall also be submitted to the Government.
- B.1.2.3.2 The Government reserves the right to screen all products and materials, based on printed information from manufacturers and information in the open literature, and to target selected products for testing.
- B.1.2.3.3 The Government reserves the right to require emissions testing of selected products, at no cost to the Government, to determine chemical content, emissions rate, or change in composition due to environmental exposure. Based on test results, the Government reserves the right to disallow installation of a given product or material in the completed facility. All testing will be by the suppliers, with test guidance provided by the Government. The design professional shall coordinate this process.
- B.1.2.3.4 Material selection, modification, and handling shall minimize indoor air pollution.

B.1.2.4 RESULTS OF MATERIALS EVALUATION

- B.1.2.4.1 The results of the process must be the selection and appropriate installation of materials that have low content of toxic or irritating chemicals and that have stable chemicals (low emissions). The design professional may be required to computer-model selected materials for the purposes of exposure assessment. Details of the materials evaluation process are presented in the Supplemental Indoor Air Quality Information presented later in this appendix.

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- B.1.2.4.2 Special procedures available to prevent or remedy problems of indoor air quality that result from material emissions will be required prior to occupancy of the building. These procedures are discussed in the Supplemental Indoor Air Quality Information presented later in this appendix.

B.1.2.5 MATERIALS AFFECTING INDOOR AIR QUALITY

Careful selection and application are required for all interior finish materials and compounds that may result in indoor air residues. Particular attention should be paid to the following materials:

- Adhesives
- Sealants
- Caulking
- Wood preservatives and finishes
- Pesticides
- Fungicides
- Carpet
- Carpet padding
- Paints
- Insulations: thermal, fire and acoustic
- Wood paneling
- Composite wood products such as particle board, cardboard, wafer board, chipboard, etc.
- Gaskets
- Glazing compounds
- Control joint fillers
- Floor coverings
- Wall coverings
- Ceiling tiles, panels
- Furniture
- Systems furniture.

B.1.2.6 DESIGN

- B.1.2.6.1 The design of the HVAC system shall minimize conditions conducive to microbial growth, chemical contamination, and particulate matter releases, and distribution of such within the building. Designs shall minimize conditions of accumulated moisture that, together with warmth and darkness, encourage the growth of microorganisms.
- B.1.2.6.2 Reliable control of humidity shall be provided. Water shall not be permitted to accumulate in drain pans. Drip or drain pans must be readily maintainable. Carbon-containing materials shall be avoided in areas where water accumulates.
- B.1.2.6.3 The HVAC system must be readily accessible to allow for maintenance, frequent inspection, and cleaning of surfaces exposed to the airstream. Care must be taken to avoid use of materials that will release nonbiological particles into the airstream.

B.1.3 HVAC SYSTEM DESIGN

B.1.3.1 IMPORTANT IAQ ISSUES

Important IAQ issues are as follows:

- The selection and installation of components and materials
- Control of moisture accumulation within the system
- Delivery of required outside air to the occupants' breathing zone
- Design of a readily maintainable system

- Implementation of energy management strategies that do not compromise indoor air quality
- Space air distribution (both supply and return)
- Humidity control
- Isolation zones for IAQ control.

B.1.3.2 VENTILATION STANDARD

- B.1.3.2.1 ASHRAE standard 62-1989, Ventilation for Acceptable Indoor Air Quality, shall be followed. Additionally, requirements of Section 15, Mechanical Requirements, of this Manual shall be followed. Certain aspects of the ASHRAE standard are highlighted within this document.
- B.1.3.2.2 Emphasis on maintenance of ventilation system equipment is presented in terms of “readily maintainable” installations. This is a change from earlier language, which read “readily accessible.”

B.1.3.3 OUTSIDE AIR SUPPLY

- B.1.3.3.1 The HVAC system design must reflect the anticipated ventilation efficiency as the basis for assumptions that result in the sizing of equipment that impacts outside air supply quantities.
- B.1.3.3.2 The general office minimum ventilation rate is 20 cubic feet per minute (cfm) per person. This refers to the quantity of outside air actually delivered to the breathing zone. Maintaining this rate will require a larger quantity of outside air at the building intakes to compensate for ventilation efficiency below 100 percent. Twenty cfm per person is the required minimum quantity of outside air delivered to the occupants under conditions of minimum outdoor air supply. Where multiple spaces with dissimilar ratios of outside air to total air are served by a common air supply system, air quality shall be determined by Equation 6-1 of ASHRAE standard 62. Performance will be determined by tracer gas injection at the supply fan and measurement at representative locations.
- B.1.3.3.3 It is important to note that the minimum outside air requirements in the ASHRAE standard are predicated on an indoor environment that is free of significant sources of pollution.
- B.1.3.3.4 The presence of unavoidable sources of pollutants will require a higher percentage of outside air supply. Thus, the HVAC system must be capable of providing and sustaining higher outdoor air supply rates.

B.1.3.4 AIR CLEANING

- B.1.3.4.1 The facility will utilize the most technologically advanced and cost-effective techniques to minimize the presence of gas, vapor, and particulate phase pollutants to the maximum practical extent.
- B.1.3.4.2 The trade-offs between cleaning and recirculating return air and conditioning outside air vary greatly from time to time. The HVAC system and the building automation system (BAS) must be capable of detecting critical factors that will allow the automatic selection of the most cost-effective mix of air cleaning, outside air supply volume, and recirculated air. The critical factors are the thermal properties and contaminant contents of both the outside air and the return air relative to the design conditions.
- B.1.3.4.3 **OUTSIDE AIR CONTAMINANTS**
Air-cleaning devices (e.g., scrubbers) may be required that are capable of removing outdoor pollutants that periodically exceed established standard (National Ambient Air Quality Standards [NAAQS] and Table E-1, Ambient Air Quality Guidelines) from ASHRAE standard 62-1989. This may involve the provision of air cleaning beyond the usual panel type particulate filters currently used in most commercial building. However, as stated earlier, precipitators, absorption and

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scrubbing should be avoided because of their high maintenance costs. Where proposed, a cost/benefit study must be submitted.

B.1.3.4.4 RE CIRCULATION AIR CONTAMINANTS

Furthermore, additional air-cleaning technologies must be used, if necessary, to achieve acceptable indoor air quality where recirculation air contaminant levels result in supply air quality problems.

B.1.3.5 SPACE AIR DISTRIBUTION

B.1.3.5.1 This method of indoor contaminant control presents a large potential for significant improvement in ventilation efficiency and, thereby, in indoor air quality. Poor ventilation efficiency results in deterioration of indoor air quality and increased operational costs. The Government requires that the design professional address the ventilation efficiency of the system.

B.1.3.5.2 The Government requires that Air Distribution Performance Index (ADPI) exceed 80 percent and that the design professional describe the approach and provide calculations.

B.1.3.5.3 Ceiling plenums may be used for return air provided that sufficient return dampers and duct headers are provided to permit accurate air balancing and provided that all code wiring provisions are followed for smoke and fire safety.

B.1.4 INDOOR AIR QUALITY REFERENCE GUIDELINES

The design professional shall review and respond to the EPA publication, *Building Air Quality: A Guide for Building Owners and Facility Managers*, U.S. Department of Health and Human Services (DHHS), Center for Disease Control (CDC), National Institute of Occupational Safety and Health (NIOSH) Pub. No. 91-114, as well as the American Institute of Architects (AIA) documents composing the Environmental Resource Guide.

B.2 Supplemental Indoor Air Quality Information

B.2.1 GENERAL

The accompanying material has been provided to advise users of this Manual on the nature of testing and evaluative procedures to which the facility may be subject.

B.2.1.1 SITE EVALUATION

B.2.1.1.1 Valuable air quality and weather data are available from local air quality monitoring and regulatory agencies, National Oceanic and Atmospheric Administration monitoring stations, airports, harbors, and even certain resort and athletic establishments. Data on prior uses of sites may be available through historic building surveys or documentation, older fire insurance maps, municipal land use records, assessors' and recorders' files, and other state and local health, waste disposal, or hazardous materials control agencies.

B.2.1.1.2 A set of manuals for air quality considerations in residential planning was prepared for the United States Department of Housing and Urban Development in 1978. While written for the residential environment, the methods and procedures described there will be useful for any type of building. These manuals provide illustrative base maps, calculations sheets, and other aids for the preparation of a comprehensive assessment.

B.2.1.1.3 The following references are for the manuals cited above; they will be helpful in the site evaluation. Thuillier, R.H. 1978. *Air Quality Considerations in Residential Planning*. Volume 1. *Guide for Rapid Assessment of Air Quality at Housing Sites*. Volume 2. *Manual for Air Quality*

Considerations for Residential Locations. Volume 3. Scientific Support and Documentation.
Washington, D.C.: United States Department of Housing and Urban Development.

B.2.1.2 CONTAMINANTS SOURCE DISTRIBUTION

Table B.2.1.2, Sources Contributing to Indoor Air Pollution, provides a summary of likely sources of indoor air pollution.

Table B.2.1.2 Sources Contributing to Indoor Air Pollution	
Type of Location	Description and Characteristics
Outdoor Air	Cyclical Daily traffic patterns Diurnal thermal patterns Seasonal thermal patterns Seasonal air quality variations Daily or seasonal releases from neighboring structures or land Episodic Extreme weather conditions Accidental releases
Base Building	Building materials and equipment Exposed to interior Exposed to air distribution system Concealed
Occupants and Their Activities	Metabolic activity Work, recreational, food preparation, personal hygiene Operation of machines and equipment
Building Maintenance	Routine cleaning Dusting, vacuuming Waxing and polishing Repair of building equipment Treatment for pests, odors

B.2.1.3 BUILDING MATERIALS EVALUATION PROCESS

B.2.1.3.1 PHASE 1 - IDENTIFYING TARGET PRODUCTS

- B.2.1.3.1.1** The first step is to become familiar with the overall project, design, and space planning program; building design; and construction schedule. This understanding is essential for other tasks as well as for the building materials evaluation work. The simultaneous timing of certain construction tasks in relation to installation of major interior furnishings and workstation components increases the potential for retention of airborne contaminants from construction processes on large-surface area materials such as carpets and textiles until long after initial occupancy. Table B.2.1.3.1.1, Potential Sources of Indoor Air Pollutants, shows pollutant sources warranting particular attention.

Table B.2.1.3.1.1 Potential Sources of Indoor Air Pollutants

- | | |
|--|---|
| <ul style="list-style-type: none"> • Adhesives • Sealants • Caulking • Wood preservatives and finishes • Pesticides • Fungicides • Carpet • Carpet padding • Paints • Insulations: thermal, fire, and acoustic | <ul style="list-style-type: none"> • Wood paneling • Composite wood products such as particle board, chipboard, wafer board, cardboard, etc. • Gaskets • Glazing compounds • Control joint fillers • Floor coverings • Wall coverings • Ceiling tiles, panels |
|--|---|

B.2.1.3.1.2 This is followed by a review of the design-professional-intended use of major interior finish materials including floor coverings, wall coverings, ceiling system, HVAC duct materials, and furnishings. Considerations include the criteria for selection of certain products (for example, maintenance, cost, acoustics, aesthetics, and functional performance) as well as the quantities and applications contemplated. This review phase concludes with identification of products and materials that might emit toxic or irritating chemicals in the completed building. At this point, all questionable products and materials are considered for further screening.

B.2.1.3.1.3 The “Environmental Resource Guide” published by AIA may be of assistance in evaluating building materials.

B.2.1.3.2 PHASE 2 - SCREENING TARGET PRODUCTS

B.2.1.3.2.1 GENERAL

Screening of major components of the building fabric and furnishings is done by determining the following:

- Components’ quantity and distribution in the building
- Chemical composition
- Stability of chemical substances of concern
- Toxic or irritation potential of components’ major chemical constituents.

The result of this screening process is the identification of products and materials for further investigation.

B.2.1.3.2.2 PHASE 2 (A) - QUANTITATIVE ASSESSMENT

Quantitative use and distribution assessment involves identifying the major classes of materials, furnishings, and finishes to be used and determining the extent of use, use per unit of floor area, and potential exposure of occupants due to the nature of the product use.

B.2.1.3.2.3 PHASE 2 (B) - CHEMICAL CONTENT

At this phase, chemical content is assessed from published general information on building products and materials, information obtained from the building’s interior designers, or manufacturers’ and suppliers’ product literature and data sheets. The last are obtained by requiring all potential vendors to provide Manufacturer’s Safety Data Sheets (MSDSs) for all products assembled by them and the names of suppliers of each product not assembled by them. Additionally, manufacturers should be required to provide contact information for each of their suppliers and to request the contact individual to cooperate with the design team. These secondary suppliers and manufacturers are contacted and additional MSDSs and other information are obtained.

MSDSs are U.S. Occupational Safety and Health Administration (OSHA) mandated documents listing all hazardous substances contained in the product they cover; they are generally available for most products of interest. OSHA requires that MSDSs be available for most products of interest. OSHA requires that MSDSs be available to workers for all hazardous substances to which the worker will be exposed. Thus, whether in a factory or at the construction site, each substance used in building materials, products, and furnishings is theoretically covered by an MSDS.

B.2.1.3.2.4 PHASE 2 (C) - CHEMICAL STABILITY

Stability (chemical emissions) assessments are done by reviewing the vapor pressure and molecular weight data for chemicals of concern, as identified on the MSDSs. Many sources can be used to obtain the data:

- American Conference of Government Industrial Hygienists, 1988. *Industrial Ventilation: A Manual of Recommended Practice*.
- National Institute of Occupational Safety and Health 1982, 1984. *Registry of Toxic Effects of Chemical Substances*. 1981-1982. Volumes 1-3 (RTECS) plus the RTECS 1983-4 Supplement (2 volumes).
- National Institute of Occupational Safety and Health 1985. *Pocket Guide to Chemical Hazards*.
- Sax, N.I. 1979. *Dangerous Properties of Industrial Materials*. 5th Edition. New York: Van Nostrand Reinhold.
- Verschueren, K. 1983. *Handbook of Environmental Data on Organic Chemicals*. 2nd Edition. New York: Van Nostrand Reinhold.

Additional information on potential emissions into building air is obtained by reviewing emissions test reports and articles in the published literature. See especially:

- Tucker, W.G. 1986. "Research Overview: Sources of Indoor Air Pollutants." in *Proceedings of IAQ '86, Managing Indoor Air for Health and Energy Conservation*. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
- Levin, H. 1987. "The Evaluation of Building Materials and Furnishings in New Buildings." in *IAQ '87, Practical Control of Indoor Air Quality*. Atlanta, Georgia: American Society for Heating, Refrigerating and Air-Conditioning Engineers.

Emission factors can vary significantly—up to a factor of 1,000—for different brands of similar products. Therefore, it is important to obtain as much information as possible about the identity and quantities of constituents in a given product. While such a paper evaluation cannot be definitive, it can be useful in selecting potentially acceptable products. It also can be useful in identifying specific compounds to be measured if laboratory testing is performed.

B.2.1.3.2.5 PHASE 2 (D) EXPOSURE AND TOXICITY EVALUATION

- B.2.1.3.2.5.1 Toxicity and irritation potential of the constituent compounds are evaluated using standard reference sources (ACGIH 1980). Exposure evaluations by computer modeling may also be required.

- American Conference of Governmental Industrial Hygienists, Inc. Documentation of the threshold limit values, 4th ed. Cincinnati.
- Gosselin, G.D., and F.C. Clayton, eds. 1981. *Patty's Industrial Hygiene and Toxicology*. 3d rev. ed. Volumes 1-3. New York: John Wiley and Sons.
- NIOSH. 1983. *Registry of Toxic Effects of Chemical Substances*. 1981-2, Volumes 1-3. Cincinnati: National Institute of Occupational Safety and Health, U.S. Public Health Service.
- NIOSH. 1985. *Registry of Toxic Effects of Chemical Substances*. 1983-4. Supplement, Volumes 1-2. Cincinnati: National Institute of Occupational Safety and Health, U.S. Public Health Service.
- NIOSH. 1985. *Pocket Guide to Chemical Hazards*. Cincinnati: National Institute of Occupational Safety and Health, U.S. Public Health Service.
- Olishifski, J.B., ed 1979. *Fundamentals of Industrial Hygiene*. National Safety Council.
- Sax, N.I. 1979. *Dangerous Properties of Industrial Materials*. 5th ed. New York: Van Nostrand Reinhold.
- Sparks, L. 1989. *IAQ Model*.

B.2.1.3.2.5.2 Sax (1979), for example, lists a "summary of toxicity statement" or rating (THR) for each substance covered. Ratings of "none," "low," "moderate," "high," or "unknown" are given. The route or routes of entry are given for specified toxic effects. LD50 (lethal dose for 50% of experimental animals) are given for various exposure routes, tests and experimental species. Human irritation potential and target organs or sites are also listed, and carcinogenicity and mutagenicity assessment is reported.

B.2.1.3.2.5.3 NIOSH's *Registry of Toxic Effects of Chemical Substances* 1981-1982. Volumes 1-3 (RTECS) plus the RTECS 1983-4 Supplement (2 volumes) provide an annotated listing of toxicity and irritation research for tens of thousands of chemical substances. RTECS also provides a comprehensive list of alternative trade and generic names by which products may be known or marketed, chemical formulas, and cross-references to the Chemical Abstracts Service (CAS) number for each chemical.

B.2.1.3.2.5.4 A database on building materials emission rates is now being developed by EPA. There is also a large database developed by the National Aeronautics and Space Administration (NASA) for spacecraft design and operation. Work currently in progress will make both of these databases accessible and useful at this point in the process. From this review, determinations are made regarding materials that will require laboratory testing according to the outcome of the combination of reviewed factors. A combination of high volatility and moderate toxicity would result in further consideration of the substance and the product. A very low volatility and moderate toxicity would be examined in terms of the quantity of the product and the quantity of the substance present in that product. No algorithm has been established for this evaluation; a qualitative assessment is the most reasonable approach given the limited amount of data currently available.

B.2.1.3.2.6 RESULTS

The results of this screening process allow identification of the products most likely to emit significant quantities of irritating or toxic substances. These are likely to be the carpet system

(carpet, pad or backing, and adhesive), workstation (office furnishings) work surfaces and interior partitions, and ceiling tiles. Shelving materials, adhesive, caulking compounds, and some wood finishes are also materials of concern. These materials should be evaluated by emissions testing.

B.2.1.3.3 PHASE 3 - EMISSIONS TESTING

B.2.1.3.3.1 Test methods include bulk testing and environmental chamber and headspace air sampling. Air sampling can also be done in the first completed building prior to, during, and after materials installation to develop air quality profiles of the installation. Chamber tests can be conducted in a very small chamber (less than 0.1 cubic meter) or in a medium-size chamber capable of accommodating full-size samples.

B.2.1.3.3.2 Cut samples create problems of distorted ratios between surface area and edges, and cuts through materials can expose materials not normally exposed in the assembled product. Sealing the edges reduces some of these effects. Room-size chambers can also be used, but they are expensive and require larger quantities of materials.

B.2.1.3.3.3 Ratios of materials, surface area, and weight to chamber volume and wall area should be kept reasonably similar to the ratios found in actual building situations. Multiple materials tests may also be run to determine “sink” effects, the tendency of materials to absorb airborne substances on their surfaces and rerelease them to the air.

B.2.1.3.3.4 Air movement, temperature, and relative humidity, as well as outdoor (or pure) air exchange rates in the chamber should approximate those found in buildings. Airflow should be controlled within the chamber to ensure good mixing and to minimize unusually high velocities at material surfaces. Guidance is available from *A Standard Guide for Small-Scale Environmental Chamber Measurements of Organic Emissions from Indoor Materials / Products* now under development by ASTM Subcommittee D-22.05 on Indoor Air (1916 Race St., Philadelphia, PA 19103).

B.2.1.3.3.5 Material samples are generally conditioned by being placed in the chamber at controlled temperature and under forced air circulation for several hours or even days prior to testing. In order to best meet the purpose of the testing, handling of the material should resemble that employed in actual installations of the materials in buildings. Products are stored in factory containers until testing. Once opened, they are kept in a normally ventilated room containing typical, new office furnishings until additional testing is conducted. Complete and careful recordkeeping is essential to interpretation of testing results.

B.2.1.3.4 ANALYSIS AND RECOMMENDATIONS

Based on the results of the four-phase materials evaluation process, products can be selected, modified, treated, or otherwise managed to improve indoor air quality.

B.2.1.3.5 DEFINITIONS

B.2.1.3.5.1 BREATHING ZONE

The air space bounded by the lower and upper horizontal planes where human respiration occurs. For office space, this zone is between 42 and 64 inches above the floor. All breathing zone measurements shall be made at a height of 42 inches.

B.2.1.3.5.2 ROOM VENTILATION EFFICIENCY

Percentage of the outdoor air entering the room per person that actually ventilates the breathing zone.

- B.2.1.3.5.3 **OVERALL (BUILDING) VENTILATION EFFICIENCY**
Percentage of the outdoor air entering the building per person that actually ventilates the breathing zone.
- B.2.1.3.5.4 **VOLATILE ORGANIC CHEMICALS**
Such compounds having vapor pressures above 0.1 mm of mercury.
- B.2.1.3.5.5 **SEMIVOLATILE ORGANIC CHEMICALS**
Such compounds having vapor pressures of less than 0.1 mm of mercury down to .0000001 mm of mercury.

B.3 Construction Process

B.3.1 GENERAL

The construction process offers many opportunities to observe and correct problems before the building is completed and occupied. As part of the Quality Assurance/Quality Control Manual, a review of change orders, shop drawings and other submittals, and installations in the field shall be used to avoid construction and occupancy delays, call-backs, and problems in the occupied building.

B.3.1.1 CHANGE ORDERS, SHOP DRAWINGS

- B.3.1.1.1 Changes made and details supplied by contractors or designers during construction can significantly affect indoor air quality. Changes made in response to previously anticipated problems or events during construction must meet the design intent and the established performance criteria outlined in the IAQ Quality Assurance/Quality Control Manual.
- B.3.1.1.2 The design professional must review, evaluate, and follow-up on change orders, field orders, and shop drawing approval requests for items determined to be significant to indoor environmental quality. These include HVAC system design and components, insulations, sealants, finish materials, and furnishings, among others. The list of items requiring special attention with respect to IAQ shall have been identified in the IAQ Quality Assurance/Quality Control Manual and the procedures and criteria for their selection specified.

B.3.2 COMMISSIONING

- B.3.2.1 Simultaneous thermal and air balance must include complete system balancing under heating, cooling, and economizer cycles. Limitations imposed by weather conditions shall be overcome by completion of the balance work at the earliest available opportunity.
- B.3.2.2 Effective training programs must be included in control system and HVAC equipment construction contracts.
- B.3.2.3 Evidence that the facility's ventilation system is fully functional and that air quality is acceptable prior to initial occupancy of any specific area will be the responsibility of the design professional. This will be accomplished through performance testing during or immediately after the "commissioning" of the completed facility.
- B.3.2.4 While no specifics for performance verification are included in the proposed OSHA 29 CFR indoor air quality standard, it is the intent that the actual facility be measured prior to occupancy and periodically after occupancy to determine IAQ conformance to ASHRAE, the requirements of this document, and other specified code and Governmental requirements in force.

B.3.3 AIR-OUT PROCEDURES

Refer to the requirements of Chapter 4, paragraph 3.b, and Chapter 7, paragraph 3.e(4), of the *Safety Manual* for off-gassing.

- B.3.3.1 An IAQ control procedure known as the “air-out” will be employed after completion of the building, commissioning of the equipment, and installation of major furnishings.
- B.3.3.2 The purpose of the air-out is to remove chemical emissions from materials in the building in order to reduce occupant exposure to these chemicals once occupancy commences. The air-out is achieved by the use of adequate ventilation for an extended period of time. This will require an additional time period of 1 to 3 weeks after commissioning and prior to occupancy.
- B.3.3.3 Some material, such as carpets and other flooring systems, may require elevated air temperatures to accelerate their chemical emissions. Refer to the IAQ Quality Assurance/Quality Control Manual and/or the building acceptance test manual for appropriate recommendations.
- B.3.3.4 Supplemental air movement devices such as portable fans shall be used to increase airflow within enclosed spaces to improve the efficacy of the air-out procedure.
- B.3.3.5 The air-out must be carefully planned and conducted to avoid adverse effects on building components and equipment. Refer to the IAQ Quality Assurance/Quality Control Manual and/or building acceptance test manual.
- B.3.3.6 Such a process requires careful planning of commissioning and occupancy. The Government will provide an occupancy schedule for purposes of planning the air-out process.

END OF APPENDIX B

Appendix C - Room Data Sheets

C.1 General

This section contains the room data sheets for various typical functional layouts for EPA laboratories and laboratory support spaces. These data sheets should be used as guides and references during the programming and design process of a specific project. Final laboratory layouts must be developed with the individual users and their research requirements as provided in Section 1, General Planning and Design Data, of this Manual. Specific criteria and requirements should be verified by the design team with EPA, local, state, and federal regulatory agencies.

C.2 Typical Room Requirements

C.2.1 ROOM DATA SHEETS

The room data sheets for typical room arrangements are shown in the following laboratory and laboratory support room layouts. Specific requirements, developed during the programming process with the individual user of the room, shall be in accordance with Section 1, General Planning and Design Data, of this Manual. The final layouts for these areas will be the responsibility of the design professional with approval by EPA.

C.2.2 STANDARDS AND SYMBOLS

Standard requirements for each area or room, as indicated in the various sections of this Manual, must also be defined for each specific laboratory facility Program of Requirements (POR). A listing and definitions of typical standard requirements, symbols, and abbreviations are provided in the following subsections as examples.

C.3 Definition of Standard Requirements

All standard requirements shall be in accordance with codes and with all other requirements of this document. The narrative description of requirements in this section and elsewhere in this Manual shall take precedence over drawings. If an item is described in the narrative but not shown in a drawing, that is not to be taken as a waiver of the requirement. The schematic drawings are provided for illustrative purposes only.

C.3.1 LABORATORY CLASSIFICATION STANDARD

The required construction for all laboratory units shall be classified as Fire Hazard Class B laboratories per NFPA 45.

C.3.2 ARCHITECTURAL STANDARDS

The following typical standards may be modified in accordance with specific project requirements.

C.3.2.1 FLOORING

Provide chemical-resistant vinyl tile or seamless vinyl flooring. When a seamless vinyl floor material is required, the base shall also be seamless and integrally coved. Floor and base materials are described in Section 9, Finishes, of this Manual.

C.3.2.2 BASE

Provide 4-inch-high vinyl or rubber base with matching end stops and preformed or molded corner units.

C.3.2.3 WALLS

Provide masonry or gypsum wallboard partitions extending from the floor to the underside of structural slab. Wall surfaces shall be painted with semigloss enamel paint. In instrumentation rooms, where sound absorption is required, walls shall be properly attenuated. Reverberating wall areas should be reduced to a minimum. See also Partitions in Section 1, General Planning and Design Data, of this Manual for flame spread and smoke development specifications.

C.3.2.4 CEILING

Finished ceilings shall be suspended acoustical tile system. Tiles shall be of a nonflaking material. Ceilings in extraction, preparation, glassware washing, microbiology, and similar wet laboratories shall be of water-resistant tile materials or painted gypsum wallboard. Ceiling height in all laboratory spaces shall be a minimum of 9 feet 8 inches.

C.3.2.5 DOORS

Open doors should not protrude more than 6 inches into exit corridors. Door sizes and hardware are as follows:

- Hallway access doors: pair doors; 3 feet (active) with 1 foot panel (top and bottom bolts at inactive); wire glass (4-inch-by-25-inch or 5-inch-by 20-inch vision panel); no threshold; Americans with Disabilities Act (ADA)–compliant hardware; automatic closure.
- Interconnecting (between laboratories): 3 feet; push plate; vision panel; dual swing.
- Interconnecting (between blocks): 4 feet (minimum) with panic bar hardware; automatic closures.
- Exterior fire doors: 4 feet with panic bar hardware; automatic closures.
- All doors shall be a minimum height of 7 feet.

C.3.2.6 CASEWORK

Laboratory casework shall be of modular design and interchangeable. Standard casework shall be of metal construction; room data sheets will indicate exceptions (wood or approved plastic laminate) to these requirements. Casework shall be as described in Section 10, Specialties, of this Manual under Laboratory Casework. Unless otherwise noted in the room data sheets, peninsulas shall not have reagent shelves. Six-inch drawers are standard in the base drawer units. All units shall include label holders on all drawers and doors.

- Vented Storage Cabinets: Vented acid/base storage cabinets shall be 3-foot-wide metal cabinets. The inner surfaces of the cabinet shall be factory coated to resist acid/base fumes and spills. One adjustable shelf shall be provided. Venting shall be as for vented chemical storage cabinets.
- Countertops: Man-made stone impregnated with chemical (e.g., acids, bases, solvents) resistant epoxies. Countertops adjacent to sinks shall have grooved drainboards. Casework along walls shall have a 4-inch-high backsplash.
- Knee Space: Unless otherwise noted in specific room data sheets, knee spaces shall be 3 feet in length and 29 inches in height.

C.3.2.7 EMERGENCY RESPONSE EQUIPMENT CLOSETS

Hallway closets approximately 3 feet by 3 feet shall be located throughout the laboratory block, with equal travel distance between closets. These closets will house laboratory supplies for spill cleanup.

C.3.3 MECHANICAL STANDARDS

C.3.3.1 HEATING, VENTILATION, AND AIR-CONDITIONING (HVAC)

The laboratory HVAC system shall be designed as a one-pass air system with exhaust through hoods where hoods are used. HVAC systems should be continuously operational 24 hours a day, 7 days a week, summer and winter. Design temperatures shall be as follows:

- C.3.3.1.1 Every laboratory room shall be controlled individually in accordance with the following: summer: 72 degrees Fahrenheit (°F) dry bulb (db) $\pm 2^{\circ}\text{F}$ and 50 percent relative humidity (RH) ± 5 percent; winter: 72°F db $\pm 2^{\circ}\text{F}$ and 30 percent RH ± 5 percent. For laboratories that are primarily instrumentation rooms, the standard shall be 72°F db $\pm 2^{\circ}\text{F}$.
- C.3.3.1.2 See also Mechanical Requirements, Section 15, of this Manual under Load Calculations for additional requirements.

C.3.3.2 EMERGENCY EYE/FACE WASH

Emergency eye/face wash stations shall be provided at a minimum of one per single module (308 net usable space feet [NUSF]) in accessible locations. These stations shall be away from fume hoods, shall require no more than 10 seconds to reach, and should be within a travel distance of no greater than 50 feet from the hazard. See Section 15, Mechanical Requirements, of this Manual for additional requirements.

C.3.3.3 EMERGENCY SHOWERS

Emergency showers shall be provided in all work areas where, during routine operations or foreseeable emergencies, areas of the body may come into contact with a substance that is corrosive or severely irritating to the skin or that is toxic by skin absorption. Emergency showers shall be in accessible locations, away from fume hoods; shall require no more than 10 seconds to reach; and should be within a travel distance of no greater than 50 feet from the hazard. See Section 15, Mechanical Requirements, of this Manual for additional requirements.

C.3.3.4 DEIONIZED WATER SYSTEM

A deionized water (DI) system shall be provided at a resistivity > 10 megaohms at tap. Refer to Section 15, Mechanical Requirements, of this Manual under Deionized Water (DI) System for specific requirements. This system may be a centralized system or several decentralized systems depending on the requirements of the specific laboratory facility.

C.3.3.5 NONFLAMMABLE-GAS DISTRIBUTION SYSTEM

Outlets shall be provided as specified in the room data sheet (exact location to be determined by the Government during design stage). See also Section 15, Mechanical Requirements, of this Manual for additional requirements. This system may be a centralized system or several decentralized systems depending on the requirements of the specific laboratory facility.

C.3.3.6 FIRE PROTECTION

The entire laboratory facility shall be sprinklered. Instrumentation laboratories shall have a preaction sprinkler system. Portable fire extinguishers shall be provided in all laboratory rooms. Refer to Section 10, Specialties, under Portable Fire Extinguishers, and Section 15, Mechanical Requirements, of this Manual for additional requirements.

C.3.3.7 FUME HOODS

All fume hoods called for in the specific design criteria of this document shall satisfy all requirements stated in Section 15, Mechanical Requirements, of this Manual under Laboratory Fume Hoods.

- Fume hoods shall be equipped with a low exhaust flow safety alarm system designed to signal unsafe operating conditions whenever fume hood velocity falls below 70 percent of specified design value. The alarm system shall consist of an audible and visual alarm to indicate malfunction or unsafe operating conditions. Additional specific standard utility and service requirements shall be indicated for each specific laboratory facility project.
- Noise Control. The noise level at the face of the hood shall not exceed 70 decibels (dB) with the system operating, nor shall it exceed 55 dB at benchtop level elsewhere in the laboratory room.

C.3.3.8 LABORATORY SERVICE FITTINGS

Laboratory service fittings for piped utilities (e.g., water faucets and spigots, gas jets or nozzles, etc.) shall have a solvent, and acid-resistant epoxy-powder coating or shall be made of polyvinyl chloride (PVC) or equivalent corrosion-resistant materials where required.

C.3.4 ELECTRICAL STANDARD

C.3.4.1 ELECTRICAL OUTLETS

Laboratory standard electrical outlets shall be duplex convenience 20 ampere (amp)/120V outlets in surface metal raceways as defined in Section 16, Electrical Requirements, of this Manual. These outlets should be provided in addition to specific electrical outlets called for or shown in the respective room data sheets, and in addition to outlets needed to feed the equipment used in each room. These outlets shall be located either on the reagent shelf or, if no reagent shelf is required, 8 inches above countertop level when base cabinets are used, and 44 inches above floor level in other locations. The maximum spacing between outlets shall be 3 feet.

Additional requirements are as follows:

- Peninsulas Without Reagent Shelf. Provide a quadruplex pedestal or other type of outlet every 3 feet in the center of the peninsula; pedestal units shall have brass, waterproof covers.
- Peninsulas With Reagent Shelf. Provide duplex outlets in surface metal raceway every 3 feet flush along the face of the bottom shelf on each side of the peninsulas.
- Equipment Outlet Location. Electrical outlet location shall be near the equipment to be powered; the exact location of equipment and outlets shall be determined by the Government during early design stage.
- GFCI protection shall be provided within 6 feet of water sources.

C.3.4.2 LIGHTING

Laboratory standard lighting should be fluorescent uniform lighting with two levels of lighting at benchtop and double switching. The high level should be 100 footcandles and the low level should be 50 footcandles. See also Section 16, Electrical Requirements. Pendant lighting with direct/indirect light is recommended.

C.3.4.3 EMERGENCY LIGHTING

Provide a minimum of 5 footcandles throughout exit path, including laboratory modules. See also Section 16, Electrical Requirements, of this Manual for specific requirements.

C.3.4.4 SWITCHES

Provide at least one switch for room lighting at 54 inches above the finished floor (AFF) at each door that provides hallway egress. See also Section 16, Electrical Requirements, of this Manual for specific requirements.

C.3.4.5 EMERGENCY POWER SYSTEM

Emergency power system shall be provided by a diesel-driven emergency generator. See room data sheets and Section 16, Electrical Requirements. An uninterruptible (UPS) system or systems shall be provided if required by specific laboratory facility needs.

C.3.4.6 FIRE ALARM SYSTEM

Fire alarm systems shall be provided in accordance with the criteria set forth in Section 16, Electrical Requirements, of this Manual.

C.3.4.7 TELEPHONE OUTLETS

Telephone outlets shall be provided, one per single laboratory module space. The exact location for outlets shall be determined by the Government at an early design stage. Provide one telephone outlet per 125 NUSF of office space. If workstations are identified and are smaller than 125 NUSF, one outlet per workstation will be required.

C.3.4.8 LOCAL AREA NETWORK (LAN) COMPUTER OUTLETS

LAN computer outlets shall be provided, one per single module space. The exact location for outlets shall be determined by the Government at an early design stage. Provide one LAN outlet per 125 NUSF of office space. If workstations are identified and are smaller than 125 NUSF, one outlet per workstation will be required.







C.3.4.9 LIMS COMPUTER OUTLETS

Laboratory Information Management Systems (LIMS) computer outlets shall be provided, one per single module space. The exact location for outlets shall be determined by the Government at an early design stage. Provide one LIMS outlet per 125 NUSF of office space.
















C.3.4.10 OUTLET COVER PLATES

All telephone, computer, and electrical outlets shall be PVC or equivalent corrosion-resistant cover/face plates; metal covers shall not be used.

C.4 Laboratory Symbols ListPLUMBING SYMBOLS

A	AIR, COMP. (100 PSIG U.O.N.)	HW	HOT WATER
LA	AIR, LAB (15 PSIG U.N.O)		CUP SINK
CO2	CARBON DIOXIDE		LAB SINK
RO	REVERSE OSMOSIS WATER	 FD	FLOOR DRAIN
SS	SAFETY SHOWER	 FLD	FUNNEL DRAIN
CW	COLD WATER	 FO	FLOOR SINK
CHWS	CHILLED WATER SUPPLY		SHUT-OFF VALVE
CHWR	CHILLED WATER RETURN	EW	EYE WASH

ELECTRICAL SYMBOLS

S _D	DIMMER SWITCH		JUNCTION BOX
	20A SGL REC 120V	W 	WARNING LIGHT
	20A DUPLEX REC 120V		LIGHT FIXTURE
	30A SGL REC 208V SINGLE PHASE	S 	SAFE LIGHT
	30A SGL REC 120V 208V SINGLE PHASE		DISC SWITCH
	20A SGL REC 208V 3 PHASE		TELEPHONE
	SPECIAL PWR ERC	WP	WEATHERPROOF
	PEDESTAL BOX WITH REC	EP	EXPLOSION PROOF
	SURFACE RACEWAY	EM	EMERGENCY CKT
			COMPUTER OUTLET

C.4 Laboratory Symbols List (Continued)

ARCHITECTURAL SYMBOLS



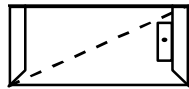
Cup Sink



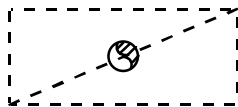
Epoxy Sink



Stainless Steel Sink



Fume Hood



Biological Safety Cabinet



Government Furnished Equipment



Umbilical 5' x 18'



Snorkle
150 cfm Exhaust (U.N.O.)

COUNTERTOP MATERIALS



Epoxy Top



Acid Resistant Plastic Laminate



Stainless Steel

APPENDIX C
TYPICAL LABORATORY ROOM EXAMPLES

EXAMPLE 1	1 MODULE LABORATORY
EXAMPLE 2	2 MODULE LABORATORY
EXAMPLE 3	2 MODULE LABORATORY
EXAMPLE 4	3 MODULE INSTRUMENT LABORATORY
EXAMPLE 5	4 MODULE CHEMISTRY LABORATORY
EXAMPLE 6	ICP-MS LABORATORY
EXAMPLE 7	VOA LABORATORY (CONTRACTOR)
EXAMPLE 8	LOW LEVEL EXTRACTION LABORATORY

ROOM DATA SHEETS

The following information shall be provided for each laboratory space.

SPACE TYPE

Information given to generally describe type of laboratory space by function.

AREA

*Information provided as part of a specific space requirement for a particular project.
Example is used to illustrate a Typical 1-Module Laboratory.*

SPACE NAME

Information provided as part of specific description of space usage for a particular project.

ACTIVITY / PROGRAM NAME

Information provided to assign responsibility for a specific space to a particular Branch / Section for a project.

OCCUPANCY

Identifies number of personnel in a given space for a defined period of time.

BUILDING SECTION

Identifies functional grouping in which space is to be located.

ADJACENCIES

Information is to be developed during programming by the design professional in consultation with representative facility users and with approval by EPA.

OPERATION / TASK DESCRIPTION

Information is to be developed during programming by the design professional in consultation with representative facility users and with approval by EPA.

LIST OF REQUIREMENTS

Ceiling – height and type

Doors – size and type

Flooring – material

Walls – materials and finishes

Window Treatment

Special Construction – if required

Outfitting

Fixed Laboratory Equipment – list of casework requirements such as:

- Metal Casework - "C" Frame
- LF of Base Cabinets - 36 Inches High
- LF of Wall Cabinets - Glass Door
- LF Adjustable Wall Shelving - 2 Tier

- Epoxy Top
- Fume Hood with Services
- Vented Solvent Storage Cabinet Below Hood
- Vented OSHA Cabinet (30 Gallon)
- Laboratory Sink
- Cup Sink
- Laboratory Desks with Bookshelves, Tackboards and File with Storage Cabinets

Mechanical Service Requirements

- Temperature and Humidity Control
- 100 Percent Supply and Exhaust - 24 Hour-Operation

Electrical Service

- 120V/20 Amp AC at Fume Hood
- 120V/20 Amp Receptacles 24 Inches on Center in Raceway
- 208V/30 Amp-1 Phase, 4 Wire AC at Fume Hood
- Disconnect Switch at Door for 120/208V Laboratory Power
- Telephone
- Cable Tray
- Emergency Power
- Fluorescent Lighting - 100 Footcandles at 36 Inches AFF
- Security
- Computer Outlets

Plumbing/Fire Protection

- Industrial Hot and Cold Water, Sink
- Industrial Cold Water, Cup Sink
- Deionized Water
- Laboratory Drain (Acid Waste)
- Compressed Air, 15 psi Serrated Connection
- Nitrogen Cylinder
- Laboratory Vacuum
- Water Sprinklers
- Dry Chemical and Carbon Dioxide Extinguisher in Safety Niches
- Safety Shower/Eyewash Station

CHEMICALS USED IN THIS ROOM

Types and quantities used are to be identified during programming by the design professional in consultation with representative facility users and with approval by EPA. The following is used as an example:

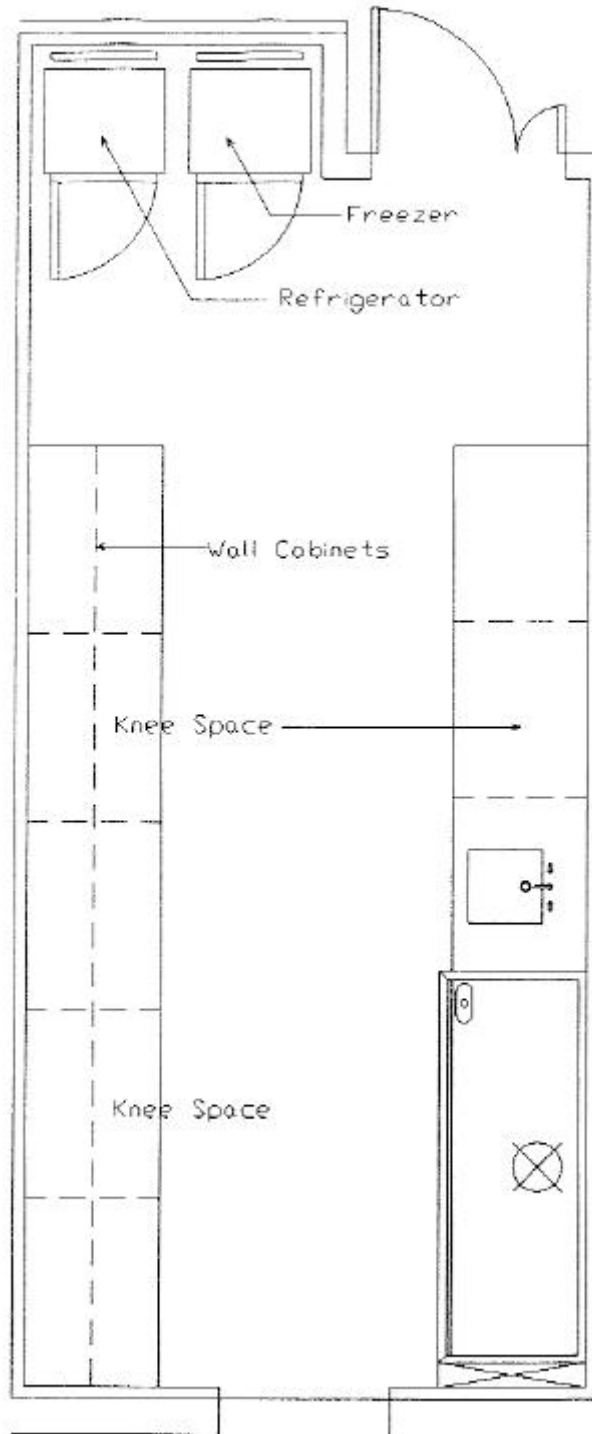
Small quantities of organic solvents, acids, and bases (generally less than 1 gallon of each at any one time) in concentrations ranging from weak solutions to concentrated materials. Standard reagent chemicals in gram proportions.

MOVABLE EQUIPMENT & FURNISHINGS

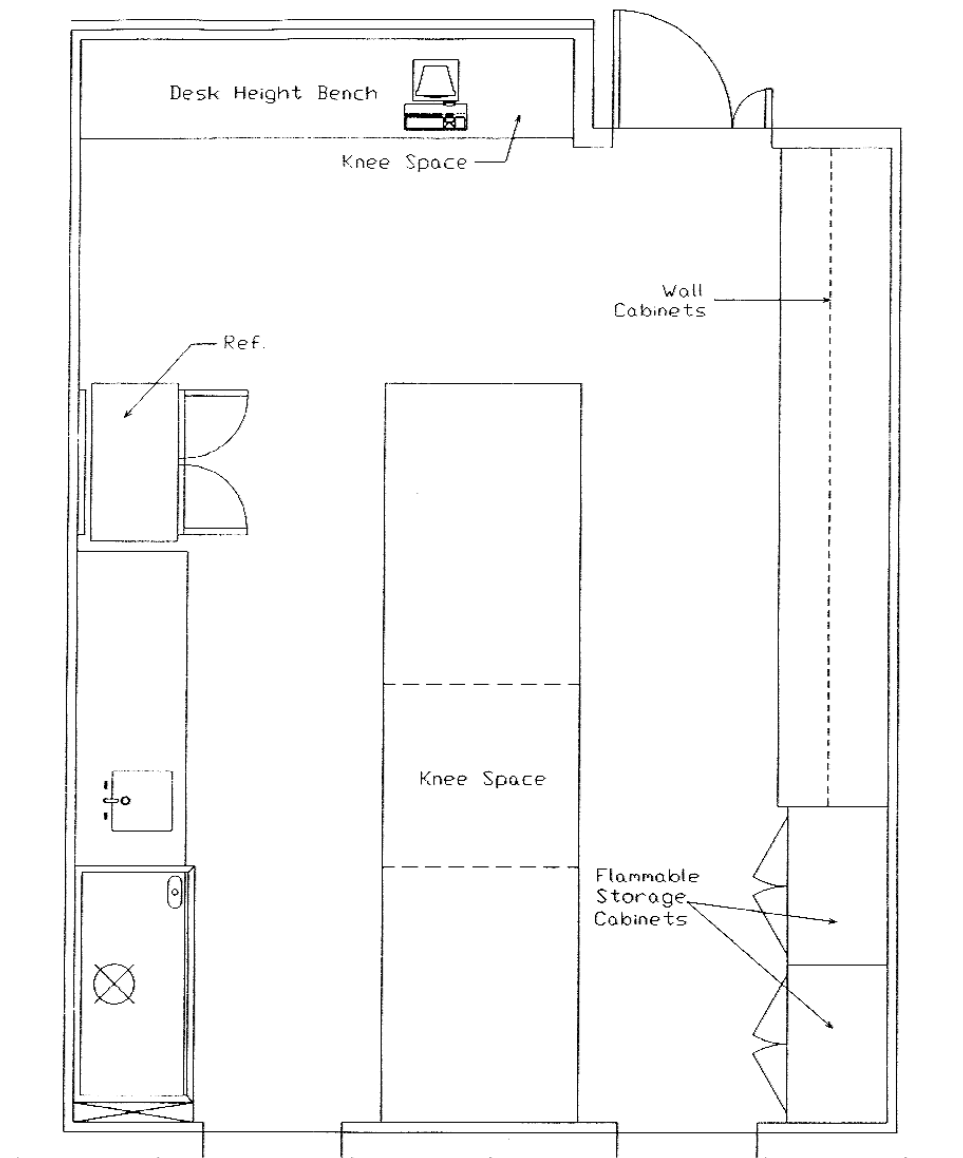
List of Government Furnished/Government Installed (GFGI) equipment and furnishings is to be identified during programming by the design professional in consultation with representative facility users and approval by EPA. The following is used as an example:

- Analytical Balances
- Bench Top Drying Ovens
- Refrigerators
- Other

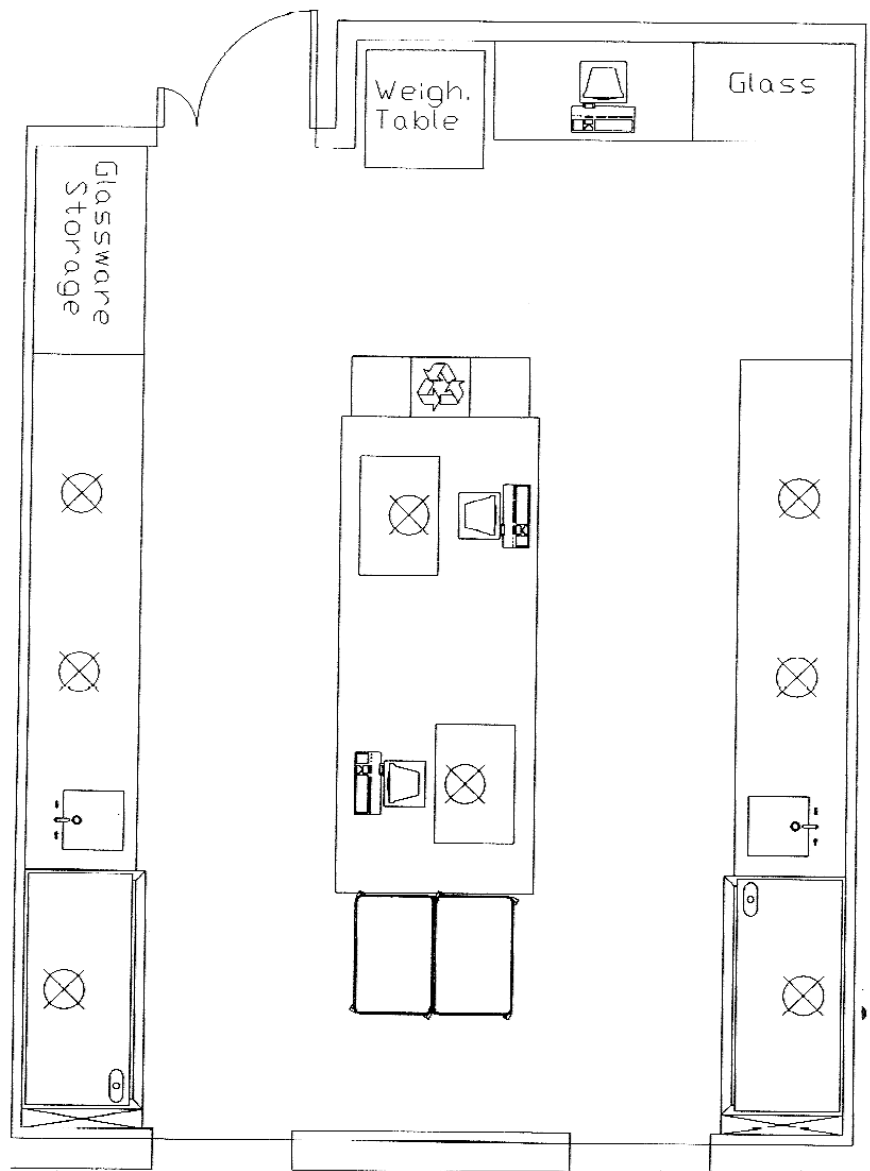
EXAMPLE 1
1 MODULE LABORATORY

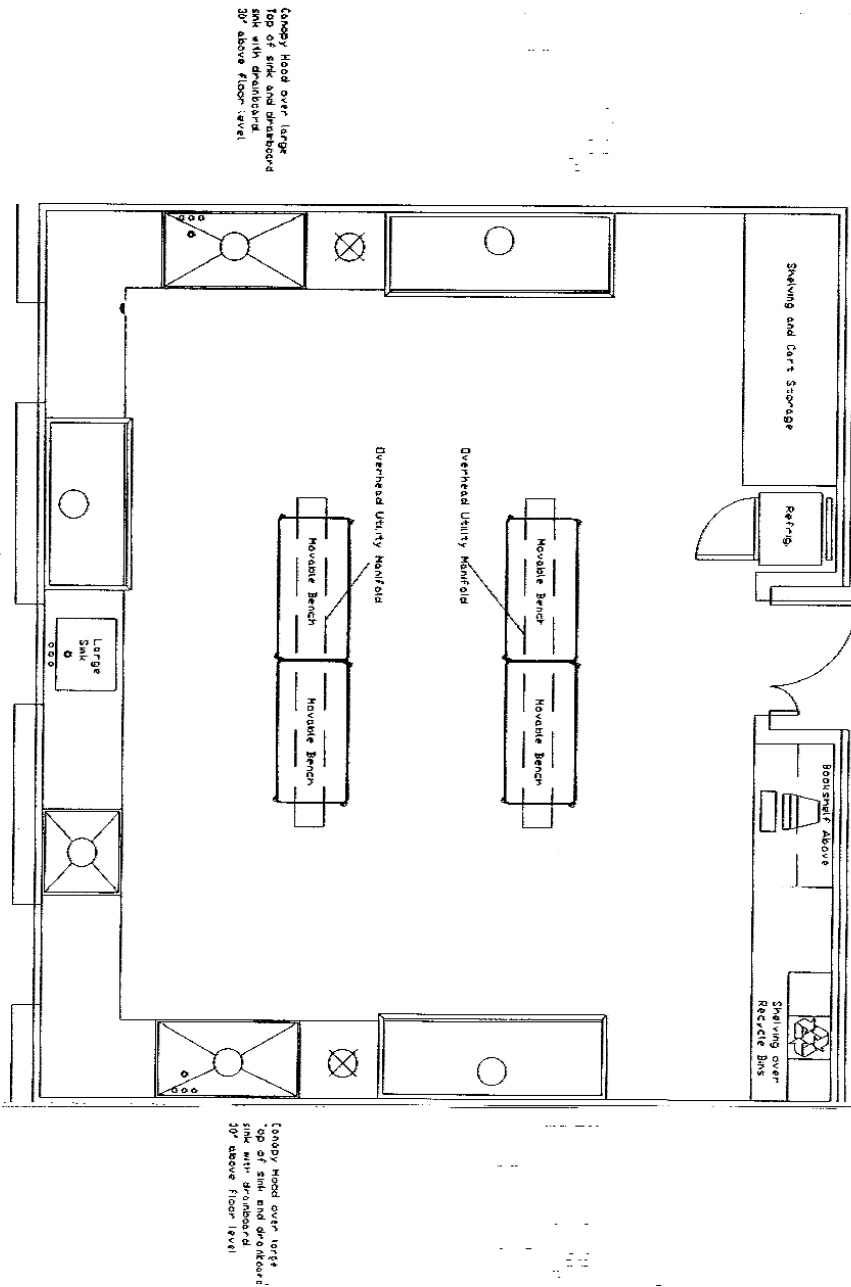


EXAMPLE 2
2 MODULE LABORATORY

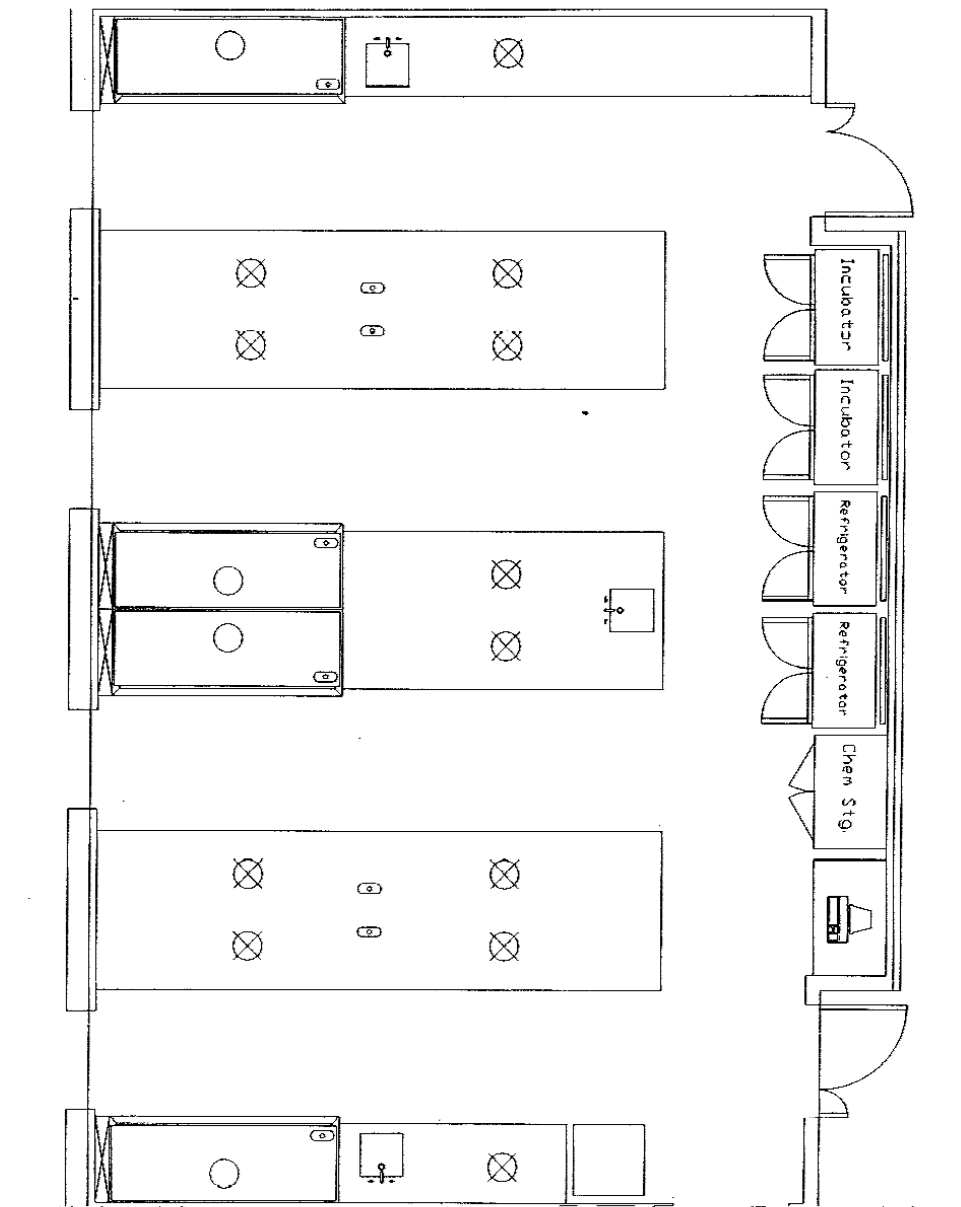


EXAMPLE 3
2 MODULE LABORATORY

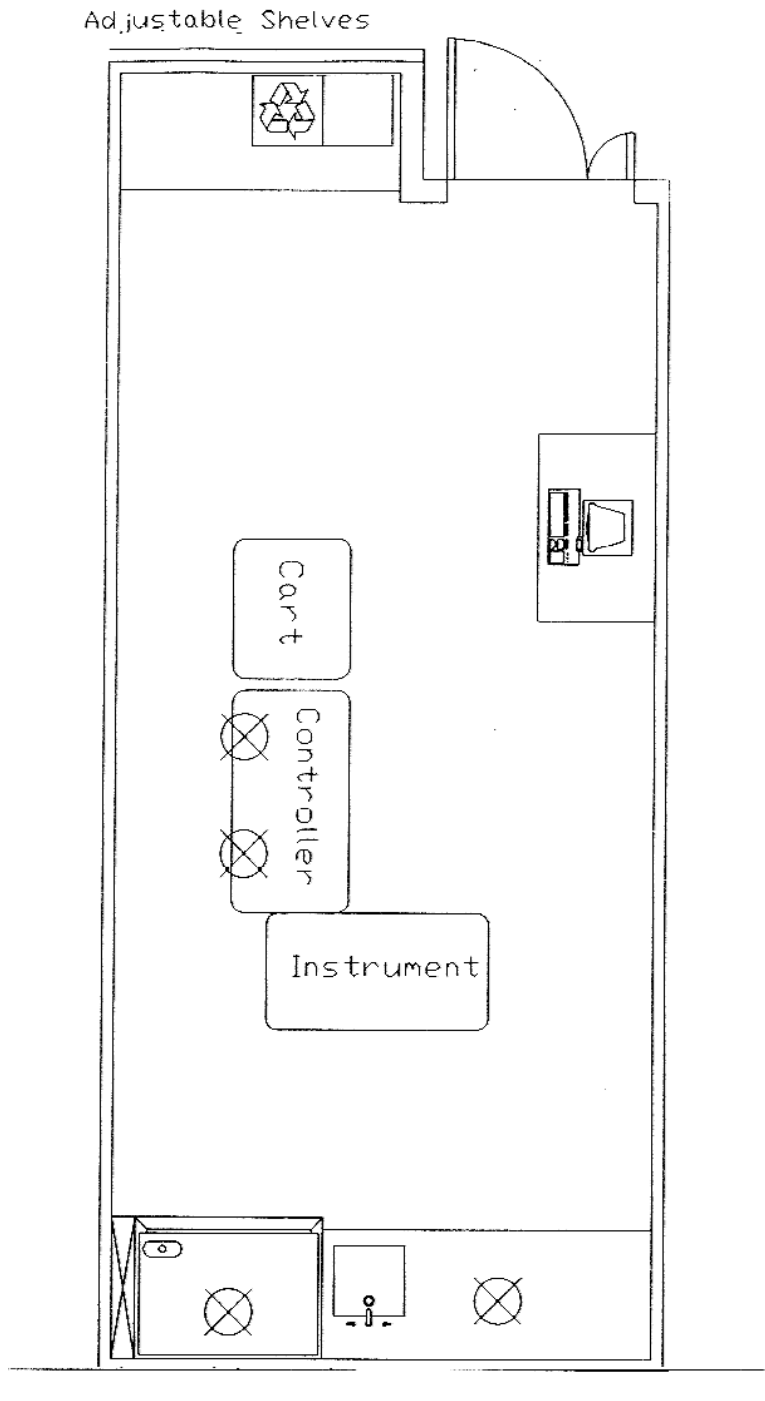


EXAMPLE 4
3 MODULE CHEMISTRY LABORATORY

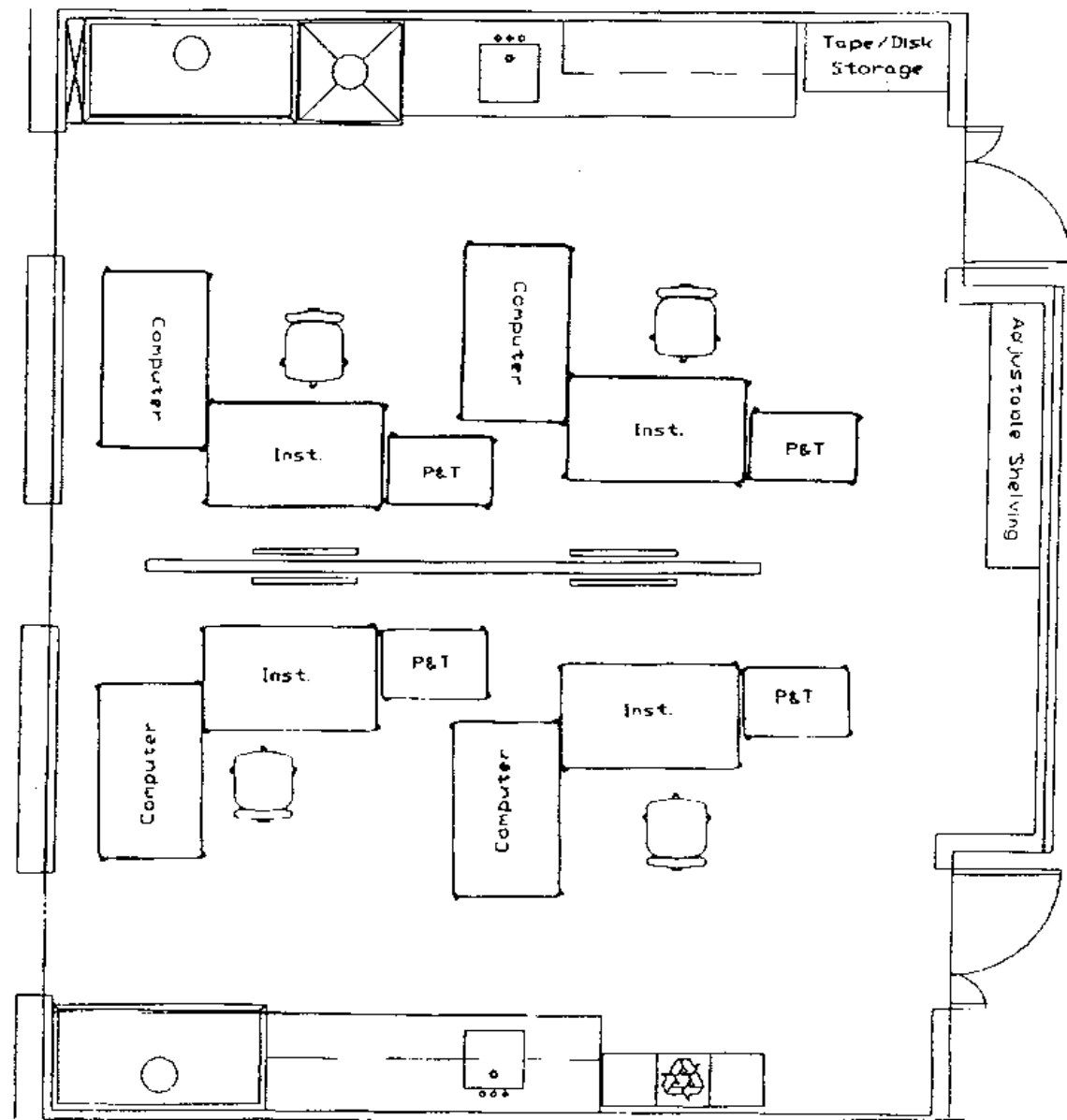
EXAMPLE 5
4 MODULE CHEMISTRY LABORATORY

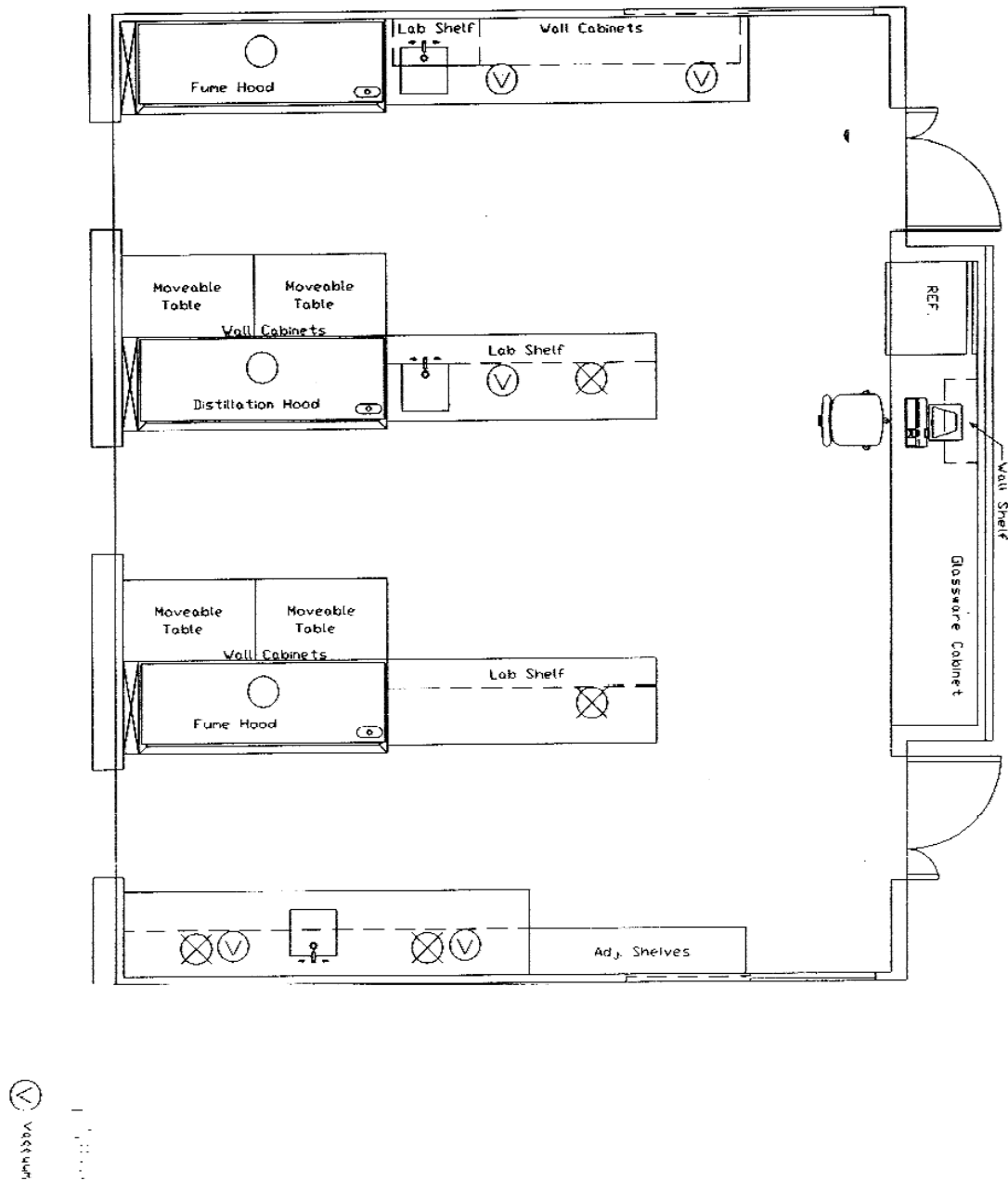


EXAMPLE 6
ICP-MS LABORATORY



EXAMPLE 7
VOA LABORATORY (CONTRACTOR)



**EXAMPLE 8
LOW LEVEL EXTRACTION LABORATORY**

Appendix D - Design Guidelines

D.1 Amenities

Amenities in laboratory facilities are spaces and/or features that provide an enjoyable environment for staff and visitors. An amenity exceeds the minimum functional requirements established by the program and may include the following:

- D.1.1 Interaction spaces, lounges, and break areas should be strategically located to foster maximum interaction while being convenient to both offices and laboratories.
- D.1.2 Conference and meeting room spaces appropriate to the laboratory/office functions should be provided in close proximity to the laboratory. The meeting room spaces should be of various sizes and shapes to accommodate a wide range of conference needs. At least one of these conference rooms should be designed to accommodate teleconferencing.
- D.1.3 Lunchroom facilities should be sized specifically to each facility. Quality design of food service areas, concession areas, and seating areas will contribute to an enhanced quality of life for the researchers. Refrigerator space must be integrated into coffee and vending areas to eliminate the temptation to store lunches in refrigerators within the laboratories. Consideration should be given to appropriate microwave and oven appliances. A “white board” for impromptu conversations should be considered.
- D.1.4 Toilets and lockers in close proximity to the laboratories and offices should be coordinated to provide maximum benefit to the staff. These facilities could be contiguous in most cases. Where appropriate, the toilet/locker combination should accommodate a shower. The shower could satisfy staff after exercise and be used to stabilize a chemical accident victim prior to medical assistance.
 - D.1.4.1 Attempt to locate lockers and toilets close to laboratories and offices in such a manner that clothing and valuables are easily accessible to the staff, precluding co-location of casework in the laboratory for personal items. Avoid placement of lockers in corridors.
- D.1.5 Space for an employee wellness center with appropriate facilities should be considered.
- D.1.6 Provide special attention to artwork and/or photos and how they are to be integrated into the design. The solution should include an integrated design for the display of research materials throughout the laboratory. Displays should be easily, quickly, and inexpensively changeable.
- D.1.7 For reasons of safety, day or elder care facilities should not be included inside a laboratory facility.

D.2 Aesthetics

Aesthetics refers to the nature of both the interior and exterior of the facility. Aesthetic considerations should include, but shall not be limited to, the following:

- D.2.1 Contextual relationship of the adjacent buildings and environment. Color, texture, and massing of building components should be investigated. Historical and contextual details should be considered.
- D.2.2 The landscape design shall integrate site and building into one concept.
- D.2.3 The sequence of access, entry, and use of the building from the viewpoint of both staff and visitor must be considered.

- D.2.4 The interior finishes must be integrated into a single concept for the entire facility. This shall include all visible materials.
- D.2.5 Consider accent and background colors, with special attention to their psychological effect on people.
- D.2.6 Consideration shall be given to lighting from the view of both visual comfort and aesthetics. Visual comfort probability (VCP) for lighting fixtures should be a factor in selection. Consider accent, indirect, artwork, and general lighting.
- D.2.7 Consider the introduction of natural light in the design. Consider methods to introduce natural light into the interior circulation spaces.
- D.2.8 Special aesthetic consideration should be given to all building entrance lobby spaces.

D.3 Interaction

Interaction of researchers is important in a research facility. There is a relationship between researcher interaction and the flow of technical information (*Managing the Flow of Technology*, Thomas Allen, 1977, 1984, MIT Press). Incorporate appropriate interaction space where feasible.

D.3.1 DESIGN CONSIDERATIONS

Design considerations to promote researcher interaction shall include, but shall not be limited to, the following:

- D.3.1.1 Communication is a function of both organization and proximity. People communicate more if they work on a similar project or are in close proximity to each other. For weekly contact, it has been shown that communication drops off dramatically after 30 meters. It is desirable to cluster researchers in 30-meter-diameter groups, with shared facilities in between these research clusters.
- D.3.1.2 Building form has an influence on communication. Whenever possible, the researchers that need to communicate should be located in close proximity on the same floor. It has been shown that floor space of less than 10,000 square meters (108,000 square feet) should be located on one floor if possible.
- D.3.1.3 The laboratory director shall be located strategically among his or her research staff. The director's office is best located toward the center of the facility. From an interaction perspective, a corner office with the best view is not the best location for the director's office.
- D.3.1.4 Offices in a cluster may be a better form to promote communication and interaction among researchers. To minimize separation, a square configuration is desirable. Buildings that are arranged in odd shapes to provide everyone with an outside office view, often compromise researcher communication. Solutions that provide for both natural light and office clusters should be strongly considered.
- D.3.1.5 When offices are put near laboratories, the researchers located in these offices have a greater sense of territoriality than if offices are farther away.
- D.3.1.6 Direct access should be provided to managers. Locating secretaries directly outside the manager's door often inhibits a subordinate from initiating informal contact with that manager.
- D.3.1.7 Library space appropriate to the laboratory/office functions should be located strategically to promote researcher interaction and efficiency.

D.3.1.8 Shared building facilities can be used as a tool to promote greater researcher communication. Place the shared facilities to provide maximum intergroup communication. Shared building facilities should be located by proximity and in locations that enhance the users' ability to positively influence researcher interaction. Shared building facilities include, but are not limited to, the following:

- Washrooms
- Copy machine areas
- Coffee areas
- Computer rooms
- Secretarial and message areas
- Computer printer terminals
- Instruction areas
- Lounges
- Special test equipment
- Libraries
- Conference rooms
- Supply rooms
- Food vending
- Common refrigerator
- Locker facilities
- Exercise facilities
- Day-care facilities
- Elevators
- Stairs
- Reception
- Drinking fountains.

D.4 Color

Color selection for building exterior and interior shall be responsive to the local environment, provide a favorable psychological effect on people, and minimize maintenance.

D.4.1 SITE CONTEXTURALISM

Color of both building and landscape elements should complement the context environment.

D.4.1.1 LANDSCAPE MATERIAL

Concepts for the design shall include the color and texture of the landscape material, how it relates to existing vegetation, how accent colors are to be used, and how color changes throughout the year. Establish a concept or strategy for landscape material selection.

D.4.1.2 SITE AND BUILDINGS

Concepts for the design shall include the color, texture, and details, and how they relate to the existing site and buildings. Establish the existing materials. New building materials shall relate to the existing materials. New details shall relate to the existing details in a coherent manner.

D.4.1.3 MAINTENANCE REQUIREMENTS

Color affects the maintenance requirements of buildings. Care should be exercised to take color and maintenance into consideration during the color selection process.

D.5 Laboratory/Office Location

There are four basic locations of researcher offices related to the laboratories: offices separate from laboratories, grouped offices across the corridor from laboratories, offices not grouped but across the corridor from the laboratories, offices not grouped but on the same side of the corridor as the laboratories.

D.5.1 ASSETS AND LIABILITIES

There are assets and liabilities for each design choice. The following questions shall be answered on a building-by-building basis. After the questions are answered, the designer needs to “test” various laboratory/office options with the users. The designer must keep in mind that clustered offices offer greater potential for researcher interaction than do offices lining the corridors.

- Do the offices require an exterior view, interior view, or no view?
- What is the relationship between secretarial support and the offices?
- What is the proportion of offices to laboratories?
- What are the user needs and how do they affect office configuration and location?
- How are the laboratories to be configured?
- How should the offices relate to the laboratories?
- What are the sizes of the offices?
- Are there any special psychological influences regarding office location?
- Who will use the offices?
- Where will technicians be located?
- Is constant visual supervision over the laboratories required?

D.5.2 DESIGN CONSIDERATIONS

The following design considerations should be kept in mind while configuration is under design.

D.5.2.1 OFFICES SEPARATE FROM LABORATORIES

Advantages:

- Noise or vibration to offices is minimized.
- Some offices may need to be separated from prime researchers to foster other administrative needs.
- In renovated building solutions, the close proximity of laboratories and offices may not be an option due to other factors.
- There is less researcher territoriality of laboratories if researchers are farther from their laboratories.
- Separate heating, ventilation, and air-conditioning (HVAC) system allowing for recirculated air, thereby reducing operational costs.

Disadvantages:

- Longer circulation between offices and laboratories.
- Reduced researcher interaction unless offices are clustered.

D.5.2.2 OFFICES NOT GROUPED BUT ACROSS THE CORRIDOR FROM THE LABORATORIES

Advantages:

- Close office laboratory relationship reduces walking distance for researchers.
- Very efficient use of a double-loaded corridor.
- Relatively easy to integrate this massing into an easy and efficient structural solution.
- Relatively contiguous building mass that will be more energy efficient than other solutions.

Disadvantages:

- The advantages of clustering offices in terms of interaction are not possible.
- Exterior light normally does not penetrate wall to the corridor or to the laboratories unless clerestory lighting is used.
- Promotes an uninteresting corridor environment.
- Promotes territoriality of laboratory space.

D.5.2.3 GROUPED OFFICES ACROSS THE CORRIDOR FROM LABORATORIES

Advantages:

- Offices in relatively close proximity to laboratories.
- Outside light to offices, laboratories, and corridors.
- This concept presents increased opportunity for researcher interaction.
- Offices are slightly removed from laboratories, thereby reducing noise and vibration to and from offices.
- Allows offices to be on separate HVAC system from the laboratories, thereby reducing operational costs.

Disadvantages:

- Does not provide flexibility in reconfiguration of office space.
- The clustered office configuration significantly increases the exterior envelope of the building, resulting in higher energy and construction costs.

D.5.2.4 OFFICES NOT GROUPED BUT ON THE SAME SIDE OF THE CORRIDOR AS THE LABORATORIES

Advantages:

- Provides close proximity to the laboratories, which reduces walking time between offices and laboratories.
- Provides greater safety due to the almost constant supervision of the research laboratories.
- Promotes natural lighting to corridors since exterior is not lined with offices.

Disadvantages:

- Office dimensions are more controlled by the laboratory module than other concepts.
- Because the office is between the corridor and the laboratory, the amount of light available to the laboratory tends to be reduced.
- Premium cost for office space in locations better allocated for laboratories or laboratory support.
- HVAC costs cannot be reduced because office space is on laboratory ventilation system.

D.6 Lockers and Showers

Lockers must be provided for both sexes. Each locker room can be designed as a separate element or integrated into a locker/toilet/shower group. There are some advantages to providing these functions in a coordinated group.

- Utilities are clustered for service to both toilet and shower areas.
- Duplicated functions in these areas can be eliminated.
- Close proximity provides greater efficiency in use of facilities.

D.7 Environmentally Conscious Design

EPA's objective is to foster environmentally conscious design in its facilities. To that end, consideration must include, but shall not be limited to, the following:

- Site planning that is environmentally based.
- Facility designs that reflect environmental as well as energy conscious concepts.
- Material selection based on low energy consumption both in the production and in transportation to the site.
- Material selection based on using indigenous materials and refraining from using ecologically sensitive materials.
- Material selection based on reducing hazardous chemicals within the buildings due to off-gassing of material.
- Material selection based on the products' life cycle energy use.
- Ecologically sensitive use of water within the facilities.
- Sensitive use of HVAC components to reduce pollution, conserve energy, and maintain the appropriate quality for the interior environment.
- Concepts that focus on recycling of materials.

D.8 Office (Administration)

The administrative offices shall be designed considering the following factors:

D.8.1 CIRCULATION PATTERNS OF VISITOR GROUPS

If there are visitors expected at the facility, the design shall accommodate not only tour groups, but all other visitors and their potential circulation patterns from the administration area to their destination point. Staging areas for tours should be anticipated.

D.8.2 CIRCULATION PATTERNS OF RESEARCH STAFF

Often, the placement of administration and administration support between research groups will foster intergroup interaction. Consider researchers' interaction as a prime determinant for location of administration and administration support.

D.8.3 EFFICIENT ACCESS TO ADMINISTRATIVE SUPPORT AREAS

The use of and control over administration support functions necessitate their close proximity to administrative offices, especially the resource center and meeting rooms.

D.8.4 SUPPORT SPACE FOR ADMINISTRATION OFFICES

The support space shall include, but shall not be limited to, the following:

- Security control / reception
- Conference room
- Teleconference room
- Storage
- Copier
- Coffee area/vending
- Computer access/printer output
- Visitor information center.

D.8.4.1 SECURITY CONTROL/RECEPTION

Security control shall be at the main entrance to the facility. The security control area shall have good visual control over the building entrance and lobby area. Administrative areas shall be in close proximity to the security control to provide reception function activities to support the security control staff.

D.8.4.2 CONFERENCE ROOM

Conference room areas must be sized in proportion to the number of staff and conference activities anticipated. In most building programs, conference room areas have been under programmed. The proper and adequate design of conference space for administrative areas and research areas reduces travel time and promotes interaction. "Satellite conference rooms" can also double as "satellite resource centers" for periodicals related to special laboratory groups.

- D.8.4.2.1 Conference areas that are centrally located for general administrative meetings are often designed to be subdivided with the use of folding sound-resistant doors. A vending area and related seating area may be coordinated adjacent to the main conference area to provide a broader use of the conference area. When conference areas and food-related areas are adjacent to one another, walls and doors must provide adequate sound control.

D.8.4.3 TELECONFERENCE ROOM

The teleconference room shall be designed to meet the specific teleconferencing needs of the facility. Additional issues to resolve include:

- Number of participants anticipated
- Special lighting requirements
- Special acoustic requirements
- Acoustic isolation from adjacent spaces
- Storage requirements
- Control room requirements
 - Determine whether a common control room for two conference rooms is required
 - Define control room requirements
 - Identify equipment requirements
 - Is a control room even required.

D.8.4.4 STORAGE

Storage areas adjacent to administrative offices are required to hold paper stock and miscellaneous equipment storage. Storage areas are often underprogrammed in facilities. Special attention shall be exercised regarding the need for storage space to hold extra supplies related to administrative conference space (e.g., tables, chairs, overhead projectors, slide projectors, and easels).

D.8.4.5 COPIER

Copier area shall be provided in close proximity to administrative areas. It shall be located to promote researchers/staff interaction. Area shall be exhausted to the outside to provide adequate air quality. Adequate space adjacent to the copier is needed for proper storage, recycle paper bins, and collating or layout areas for sorting copies.

D.8.4.6 COFFEE/VENDING

A coffee/vending area shall be strategically located within a short travel distance from the area serviced. The coffee/vending area should be located to promote communication and researcher interaction. Adequate area shall be provided for storage of various kinds of recycled products. Often coffee/vending areas are co-located with concession purchased items. Special attention must be given to designing concession areas for both functional use and good aesthetic design.

D.8.4.7 COMPUTER ACCESS / PRINTER OUTPUT

Computer areas including computer staff offices, paper storage and computer tape storage are often designed into a “computer suite.” Often, the “suite” will include printer output areas.

- D.8.4.7.1 The computer area shall be located as centrally as possible to reduce travel as well as wiring to computer terminals. The computer printer output areas are good interaction areas for researchers and should be located to promote interaction.
- D.8.4.7.2 Special care is required to design both floor loading and fire ratings for film and paper storage areas. Special fire protection consideration is required for the computer areas. A preaction fire protection system shall be a part of the fire protection analysis for these areas.
- D.8.4.7.3 Computer areas will probably have access flooring that may require accessible ramps (Americans with Disabilities Act [ADA] compliance required) to these areas. Special acoustical consideration is required in computer and printer output areas. If a glass wall is used to view into the computer area, adequate attention shall be given to fire protection of this glass wall.

D.8.4.8 VISITOR INFORMATION CENTER

If the laboratory will be open to domestic and/or foreign visitors, a visitor center should be considered. A visitor center shall include, at a minimum, the following amenities:

- Relaxation area
- Projection/sound equipment
- Large screen television with video cassette record (VCR)
- Coffee area.

D.8.5 SIGNAGE

Provide coordinated and integrated signage in compliance with ADA requirements. The signage solution should encompass the following:

- Exterior facility signage
- Directory signage (lobby)
- Directional signage
- Room signage (integrate with safety information)
- Employment information
- Employee photo information
- Current events notices
- New publications display
- Position opening notices.

D.9 Laboratories

The laboratory layout results from an in-depth analysis of research type, workflow patterns, and relationships to support spaces and other laboratories.

D.9.1 MODULE

A laboratory module is usually 11 feet in width and between 26 and 33 feet in length. Laboratories with heavy instrumentation requirements may require the wider module due to equipment wire and service access.

D.9.2 DISTRIBUTION OF SERVICES

An important consideration for the laboratory design is the distribution of services on a modular basis within the laboratory. Special design attention shall be paid to location of structural members related to penetrations for services along the walls and near the benches located in the center of the laboratory.

D.9.3 FUME HOOD PLACEMENT

Fume hood placement is important and shall be away from egress and circulation patterns. A 5-foot minimum aisle width shall be maintained in front of fume hoods. It is good design practice not to have “dead-end” circulation patterns that may trap an individual in case of a laboratory accident. Two means of egress from a laboratory with any fume hood are required. Refer to Chapter 5, paragraph 12, of the *Safety Manual* for additional requirements.

D.9.4 EYEWASH AND SAFETY SHOWER

Eyewash and safety shower placement is important. A good location for both safety items is at the hinge side of the egress laboratory door out of the path of travel. A fire extinguisher location in the laboratory is preferable. Refer to Chapter 4, paragraph 16, of the *Safety Manual* for additional requirements.

D.9.4.1 SAFETY SHOWER

Safety showers shall be located in a position away from the face of a hood; if a hood accident occurs, staff will be able to use the safety shower facility.

D.9.5 ELECTRICAL PANEL/FIRE EXTINGUISHER

The electrical panel to “shut down” the laboratory may be located outside of the laboratory; if an accident occurs, researchers may exit the laboratory and “shut it down” from the outside. It is good practice to locate a fire extinguisher in the corridor outside the laboratory in addition to those located within the laboratory.

D.9.6 SIGNAGE

The laboratory signage should contain the room number, room name, occupants by name, hazardous chemicals within the laboratory, emergency telephone number, and special procedures in case of emergency. Provide coordinated and integrated signage in compliance with ADA requirements. The signage solution should encompass the following:

- Directional signage
- Room signage (integrate with safety information)
- Special chemical information for each space containing hazardous chemicals
- Employment information
- Employee photo information
- Current event notices
- New publications display
- Position opening notices.

D.9.7 DOORS

The laboratory doors shall swing in the direction of egress from the laboratory. The laboratory door consists of a 3-foot active leaf and a 1-foot inactive leaf to facilitate movement of equipment into the laboratory.

D.9.8 HVAC DIFFUSERS

HVAC diffusers shall be located so that they do not “short circuit” the airflow to a hood.

D.9.9 WALLS

Laboratory walls shall be considered for extra structural reinforcing because the potential loads they may support due to shelving or cabinets. This consideration shall include future modifications to the room layout and additional shelving or cabinet requirements.

D.9.10 LABORATORY SUPPORT

Laboratory support space shall suit the needs of the specific laboratory. In some cases, a service corridor is used for laboratory support. In some cases, special support spaces are needed between laboratories.

D.9.11 LABORATORY TECHNICIAN

It is desirable to provide work space for technicians outside of the laboratories in order to reduce their exposure to the laboratory chemicals. There is also a need to provide some work space in the laboratory for laboratory-related work. Ideally, both requirements can be met to provide the greatest productivity to technicians within the most healthful environment possible.

D.10 Library

The library shall be located with good access to storage, services elevator, and conference facilities. Additional issues are as follows:

- Type of library storage
- Computer terminals required
- Study carrels required
- Work space required
- Floor loading/structural requirements.

D.11 Outside Research Facilities

Any outside related research space shall be constructed and designed to be of a quality that is in keeping with the research complex environment.

D.11.1 EXTERIOR SPACES

The exterior spaces on the property shall be adequately secured to eliminate the potential of unauthorized individuals gaining access to the property. Potentially hazardous or accident prone exterior areas shall be secured by adequate perimeter security.

D.12 Custodial Space

Custodial space shall be strategically located on each floor for efficient maintenance with adequate storage space for cleaning equipment and supplies. Besides the custodial space located on each floor, a central custodial office, locker rooms and storage space shall be considered during the early phases of design. This area shall be located in close proximity to other building services areas.

D.12.1 SHOP FACILITIES

Shop facilities shall be located with exterior access appropriate to their function. The shop facilities shall be remotely located from vibration, noise, and dust-sensitive areas.

D.12.2 OVERHEAD HOISTS

Overhead hoist requirements shall be defined early in the programming and design phases.

D.12.3 WELDING

Welding areas shall be designed to meet all code requirements.

D.13 Loading Dock/Staging

Appropriate loading dock/staging facilities are required relative to the size, function, and material requirements of each laboratory.

D.13.1 LOADING DOCK SIZE AND REQUIREMENTS

The truck turning radius to loading facilities should be appropriate to the truck size anticipated. The loading dock might include a leveling device for accommodating different size trucks. A covered loading/unloading area is desirable.

D.13.2 HVAC INTAKE

Special care shall be exercised not to locate mechanical air intakes toward the loading dock area. Idling trucks located in loading dock areas may cause contamination of intake air.

D.13.3 VIDEO MONITORING

The loading dock area shall be considered for video monitoring for security purposes. Issues to resolve are as follows:

- Nitrogen storage requirements and location; note security fence requirements
- Breakout area size
- Bulk mail process defined
- Access for emergency vehicle and ramps
- Truck parameters (dock height, leveler requirements)
- Security requirements
- Concrete paving for loading dock area
- Dumpster and compaction requirements.

D.14 Chemical Storage

The chemical storage area location shall be researched with regard to the quantity and type of chemicals stored. Chemical storage and gas cylinder storage may be located in close proximity. Special code consideration shall be given to providing adequate fire protection and separation. Special consideration shall be given to contaminated chemicals and contaminated fire protection water. The response time of the fire department is a factor that shall be considered. Special attention shall be paid to explosion relief panels and their location and safety. Refer to NFPA 30 and 45 and Chapter 4, paragraph 10, of the *Safety Manual* for additional requirements.

D.14.1 ADDITIONAL ISSUES TO RESOLVE

- Type of chemicals to be stored
- Quantity of chemicals to be stored
- Dispensing procedures
- Explosion relief panel requirements
- Fire rating separation requirements
- Building code requirements
- Zoning requirements
- Government agency requirements
- State agency requirements
- Agency having jurisdiction
- Safety officers for facility
- Local fire marshal.

D.15 Recycling/Waste Handling

Recycling design considerations are important and must be considered at the early programming and design phases. Recycling receptacles must be sized and adequate space provided on each floor and in the central loading area. Special attention is also required in vending locations for various types of recyclables. Waste handling in laboratories with animal research requires special consideration at the early program and design stages. Early in the program and design, identify the type and size of facilities anticipated for waste storage, waste compaction, and waste removal.

D.16 General Storage

General storage is usually required on every floor. General storage facilities are the most typically forgotten or undersized spaces in EPA research facilities. In Government research facilities, where it is difficult to resolve equipment disposition, adequate storage space is critical.

D.16.1 Additional issues to resolve:

- Ensure good access to service elevator
- Size rooms with freezers relative to freezer dimensions and layout
- Check corridors for movement of equipment
- Resolve signal runs to central control area as required by program.

D.17 Food Service

Food service must be located with good access to the loading dock and the service elevator. The food service shall be as centrally located as possible with an exterior view if possible.

D.17.1 Additional issues to resolve:

- Quantity of seating required
- Type of food service to be provided
- Secondary uses of food service spaces.

D.18 Emergency Generator Location

D.18.1 Location parameters:

- Locate with fresh air intakes
- Locate with exhaust away from fresh air intakes
- Locate away from vibration, acoustic, or electrically sensitive equipment.

D.18.2 Additional issues to resolve:

- Size and shape of room, including usable space around generator
- Fuel supply and location (note code and environmental requirements)
- If located outside, determine the screening parameters of such equipment
- Exhaust requirements.

D.19 Floor Loadings

The design professional must secure any special requirements for floor loading from the Project Officer with the understanding that building codes, local codes, and agencies having jurisdiction regulate these requirements. Analysis in the early planning stages of a project is required to establish the loadings for specific pieces of equipment since these equipment loads may exceed the design floor loads. The timing and sequencing that the equipment is placed into the building must be considered; this will affect the design or construction phasing. The travel path of the equipment into the building must also be considered. The most stringent floor loading requirements shall govern.

D.20 Parking

Parking and its related circulation shall be separated from the service circulation to minimize conflicts.

D.20.1 GENERAL RULES / LOCAL CODE

Parking at EPA facilities varies with the function of the facility. Some facilities' parking accommodates approximately 19 to 24 cars per 10,000 gross square feet of building. These ranges tend to have parking problems. As a general rule, parking requirements shall follow local codes. If the parking falls under 25 cars per 10,000 gross square feet of the facility, a more detailed analysis shall be made to verify that adequate parking is provided. If local codes require more parking spaces, the more stringent requirements shall apply.

D.21 Fire Department Access

Fire department access to buildings is very important. In designing buildings, and fire department access to them, ensure that the fire access road is far enough away from the building (road to be at least 20 feet in width with the edge of the road at least 10 feet from building per NFPA 1) that the distance will not hamper fire fighting. Dead-end roadways for fire fighting vehicles shall not be allowed.

D.21.1 HIGH RISE BUILDINGS

For high-rise buildings, special attention to fire fighting apparatus areas is required. A fire control room inside the building is required.

D.21.2 AUTHORITY HAVING JURISDICTION

In conjunction with local and EPA requirements, the local fire marshal shall be consulted to address and resolve any of his special concerns.

D.21.3 ELEVATORS AND FIRE VICTIMS

Special attention shall be provided to the elevator/service elevator design and its function in a fire fighting mode. Special consideration shall be given to the removal of fire victims from the building.

END OF APPENDIX D

Appendix E - Abbreviations and Acronyms

Note: Where an acronym is shown to stand for more than one term, use in the document shall be as indicated in the specific Section.

AABC	Associated Air Balance Council		Association
AASHTO	American Association of State Highway and Transportation Officials	amp	ampere
ABS	Acrylonitrile-Butadiene-Styrene	ANSI	American National Standards Institute
AC	alternating current	APhA	American Pharmaceutical Association
ACGIH	American Conference of Government Industrial Hygienists	AQMD	Air Quality Management Division
ACI	American Concrete Institute	AREA	American Railway Engineering Association
ACMD	Atmospheric Characterization and Modeling Division	AREAL	Atmospheric Research and Exposure Assessment Laboratory
ADA	Americans with Disabilities Act	ARI	Air-Conditioning and Refrigeration Institute
ADC	Air Diffusion Council	ASCE	American Society of Civil Engineers
ADP	automated data processing	ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ADPI	Air Distribution Performance Index	ASME	American Society of Mechanical Engineers
AE&P	Architecture, Engineering, and Planning	ASTM	American Society for Testing and Materials
AEERL	Air and Energy Engineering Research Laboratory	AT&T	American Telephone and Telegraph Company
AEREB	Architecture, Engineering and Real Estate Branch	AWG	American Wire Gage
AFF	above the finished floor	AWS	American Welding Society
AGA	American Gas Association	AWWA	American Water Works Association
AHU	air-handling unit	BAS	building automation system
AIA	American Institute of Architects	bhp	boiler horsepower
AIHA	American Industrial Hygiene Association	BIA	Brick Institute of America
AISC	American Institute of Steel Construction	BOCA	Building Officials and Code Administrators International
AISI	American Iron and Steel Institute	BSC	biological safety cabinet
AMCA	Air Movement and Control		

Btu	British thermal unit	DI	deionized water
°C	degrees Celsius	DOP	dioctyl phthalate
CADD	computer aided drafting design	DOT	U.S. Department of Transportation
CCTV	closed circuit television	DTD	Developmental Toxicology Division
CDC	Center for Disease Control	EA	Environmental Assessment
CERC	Coastal Engineering Research Center	ECAO	Environmental Criteria and Assessment Office
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	EERD	Ecosystem Exposure Research Division
CFCs	chlorofluorocarbon compounds	EIS	Environmental Impact Statement
cfm	cubic feet per minute	EM	Engineering Memorandum
C-Frame	cantilevered frame	EMCS	Energy Management Control System
CGA	Compressed Gas Association	EMF	electromagnetic fields
CISPI	Cast Iron Soil Pipe Institute	EMS	Energy Management System
CFR	Code of Federal Regulations	EMT	electrical metallic tubing
CMD	Contracts Management Division	EPA	Environmental Protection Agency
CMU	concrete masonry unit	ERDA	Energy Research and Development Administration
COR	Contracting Officer's Representative	ESD	Emission Standards Division
CPSC	Consumer Products Safety Commission	ETD	Environmental Toxicology Division
CPVC	chlorinated polyvinyl chloride	°F	degrees Fahrenheit
CRF	critical radiant flux	°F db	degrees Fahrenheit dry bulb
CTI	Ceramic Tile Institute; Cooling Tower Institute	FAA	Federal Aviation Administration
CVTS	cabled video teleconference space	FFL	carpet pill test
db	dry bulb	FGCC	Federal Geodetic Control Committee
dB	decibels	FM	Factory Mutual
dBA	decibels of sound measured on an A-scale	FMSD	Facilities Management and Services Division
DC	direct current	FMSD-C	Facilities Management and Services Division - Common Facilities
DDC	direct digital controls	FMSD-O	Facilities Management and Services Division - Office Facilities
DHHS	Department of Health and Human Services	fpm	feet per minute

Appendix E

GC/MS	gas chromatograph/mass spectrometer	ICS	Industrial Controls and Systems
GDHS	geometric design of highways and streets	ICP	inductively coupled plasma
GECD	Global Emission and Control Division	ICSSC	Interagency Committee on Seismic Safety in Construction
gpm	gallons per minute	ID	inside diameter
GPS	Global Positioning System	IPCEA	Insulated Power Cable Engineer's Association
GSA	General Services Administration	"K" Rated	transformers specially constructed for use with nonlinear loads
GTD	Genetic Toxicology Division	kV	kilovolt
HAZMAT	hazardous materials	kVa	kilovolt - ampere
HCFC	hydrochlorofluorocarbon	kwd	kilowatt demand
HD	heavy duty	kwh	kilowatt hours
HEFRD	Human Exposure and Field Research Division	LAN	local area network
HEPA	high-efficiency particulate aerosol	LCC	life cycle cost
HERL	Health Effects Research Laboratory	LCCA	life cycle cost analysis
HFC	hydrofluorocarbon	LEL	lower flammable/explosive limit
HID	high-intensity discharge	LIMS	Laboratory Information Management Systems
HMSF	hazardous materials/waste storage facility	low E glass	low emissivity glass
hp	horsepower	MBMA	Metal Building Manufacturers Association
HP	high pressure	MDF	main distribution frame
HPLC	high-performance liquid chromatography	MEF	Main Entrance Frame
HRMD	Human Resources Management Division	μg/L	micrograms per liter
HTW	high-temperature water	mg/L	milligrams per liter
HVAC	heating, ventilation, and air-conditioning	MIL-F	Military Federal Specification
IAQ	indoor air quality	MRDD	Methods Research and Development Division
IBM	International Business Machines	MS	mass spectrometer
ICBO	International Conference of Building Officials	MSDS	manufacturer's safety data sheets
		N value	number of blows per linear foot

NAAQS	National Ambient Air Quality Standards	OAQPS	Office of Air Quality Planning and Standards
NAD	North American Datum	OAR	Office of Air and Radiation
NAVD	North American Vertical Datum	OARM	Office of Administration and Resources Management
NC	noise criteria	OD	Office of the Director; outside diameter
NCF	network control facility	ODF	ozone depletion factor
NC/LC	noncombustible/limited combustible	OID	Owners Insurance Underwriters
NCMA	National Concrete Masonry Association	ORD	Office of Research and Development
NCPD	National Contracts Payment Division	OSA	outside air ventilation systems
NDPD	National Data Processing Division	OSHA	Occupational Safety and Health Administration
NEBB	National Environmental Balancing Bureau	OSORD	Office of the Senior Official for Research and Development
NEC	National Electrical Code	PB	polybutylene
NEHRP	National Earthquake Hazard Reduction Program	PBX	private branch exchange
NEMA	National Electrical Manufacturers Association	PCD	Pollution Control Division
NEMA KS1.1	Safety Guidelines for the Application Installation and Maintenance of Solid State Control	pCi/L	picocuries per liter
NEPA	National Environmental Policy Act	PCI	Precast Concrete Institute
NFPA	National Fire Protection Association	PCI-MNL	Precast Concrete Institute Manual
NGVD	Navigable Ground Vertical Datum	PDU	power distribution unit
NIOSH	National Institute of Occupational Safety and Health	ph	phase
NOAA	National Oceanic and Atmospheric Administration	plf	pounds per linear foot
NRC	noise reduction coefficient	POR	Program of Requirements
NSC	National Safety Code	psf	pounds per square foot
NSF	National Sanitation Foundation	psi	pounds per square inch
NSPC	National Standard Plumbing Code	psig	pounds per square inch gauge
NTD	Neurotoxicology Division	PTI	Post-Tensioning Institute
NUSF	net usable square feet	PURPA	Public Utility Regulatory Policies Act
		PVC	polyvinyl chloride
		PVDF	polyvinylidene fluoride
		QATSD	Quality Assurance and Technical

Appendix E

	Support Division	SNAP	Significant New Alternatives Policy
R (values)	thermal resistance	STC	sound transmission class
RCRA	Resource Conservation and Recovery Act	STL	sound transmission loss
RD	relative humidity	TC	telecommunication closet
RSD	Research Support Division	TIA	Traffic Impact Analysis
RTECS	Registry of Toxic Effects of Chemical Substances	TM	Technical Memorandum
SBCCI	Southern Building Code Congress International	TSD	Technical Support Division
SCS	Soil Conservation Service	UBC	Uniform Building Code
SDR-PR	standard dimension ratio - pressure rated	U-factor	a coefficient of heat loss
SDWA	Safe Drinking Water Act	UFAS	Uniform Federal Accessibility Standards
SEFA	Scientific Equipment and Furniture Association	UL	Underwriters Laboratories Inc.
SFO	Solicitation for Offer	UPS	uninterruptible power supply
SHEMD	Safety, Health and Environmental Management Division	UTP	unshielded twisted pair
SHEMP	Safety, Health and Environmental Management Program	VAV	variable air volume
SMACNA	Sheet Metal and Air-Conditioning Contractors National Association	VOA	volatile organic analysis
		VCP	visual comfort probability
		VCR	video cassette recorder
		wb	wet bulb

END OF APPENDIX E

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The *AE&P Guidelines* is indexed by major heading, and numbers refer to subsections, not page numbers. Because the index is by heading, not subject, the index may not list all specific topics covered in the *AE&P Guidelines* or all applicable subsection numbers for a listed topic. The numbers for subsections that contain only cross-references to other sources or publications are presented in *italic* type for the reader's convenience.

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